ICE-MAN

BL-3G

Ultra stable 3-Axis Gyro

Advanced User Manual

Features

- Small size, weight and power
- USB / PC connection for set up and upgrade
- Ultra stable over temperature and time
- Operational temperature: -30 ^{0}C to +85 ^{0}C
- ST L3GD20 MEMs rate sensor
- ARM Cortex processor for control and I/O
- UART connection for system developers
- Filters
  - Low pass
  - High pass (programmable)
  - Kalman (programmable)
  - Rolling average (programmable)
  - Automatic Gain Control (AGC) option on all axes
- Control algorithm
  - PID (Proportional, Integrative, Differential)
  - All gain parameters programmable (+3 external pots)
- Input Tx/Rx matching
  - Match up to any RC transmitter
  - Allows low cost system with high end features
- Curves (input stick curves)
  - Many standard and also x4 use programmable
  - Good for aircraft control at low cost
- Mixing functions / trim
  - Flying-wing, V-tail, Flaps, Flaperon aircraft
  - Power in and out (for curve transformation)
  - Trim and range adjustments for fine tuning
- X 3 Rx inputs and X 6 outputs for control signals:
  - Pitch
  - Roll
  - Yaw
- X 4 real time programmable inputs for:
  - Gyro PID gain low / high set and rate set
  - Gyro PID gain modulation based on input
  - Gyro on/off
  - "Critical time" mode for spin / crash recovery
  - "Take off" mode for perfect cross wind take offs
  - Mixing of Z axis (yaw) mix gain control
  - Power in
  - Emergency cut off
  - 'Heading lock' gyro function (all axes)
  - 2 x Input curves switchable in real time
- 1 x UART for 16 bit raw X, Y, Z rate and 8 bit temperature digital data out and PC connection
- Highly programmable for many applications
- Variable input voltage (20v to 5v, or down to 3.3v)
- LED displays to show gyro operational
- Factory calibrated
- RoHS, “green” compliant

See videos and more details at: www.bluelight-tech.com/BL-3G.htm

Applications

- RC aircraft Stabilization (Gas / Electric)
- Multi-copter / UAV stabilization
- General Robotics

Size, power and weight

- 42 x 38 x 18 mm unit
- 45 mA when in normal operation
- Weight is 19g (0.67 Oz)

PC tool

- Intuitive and easy to use software for detailed user programming
- Graphical real time data monitoring
- Graphical matching to RC transmitter
- Graphical curve generation tool
- USB and / or UART connection

This ultra stable BL-3G MEMS based gyro is ideal for stabilizing all manor or aircraft. It is specially set up for RC flying applications.

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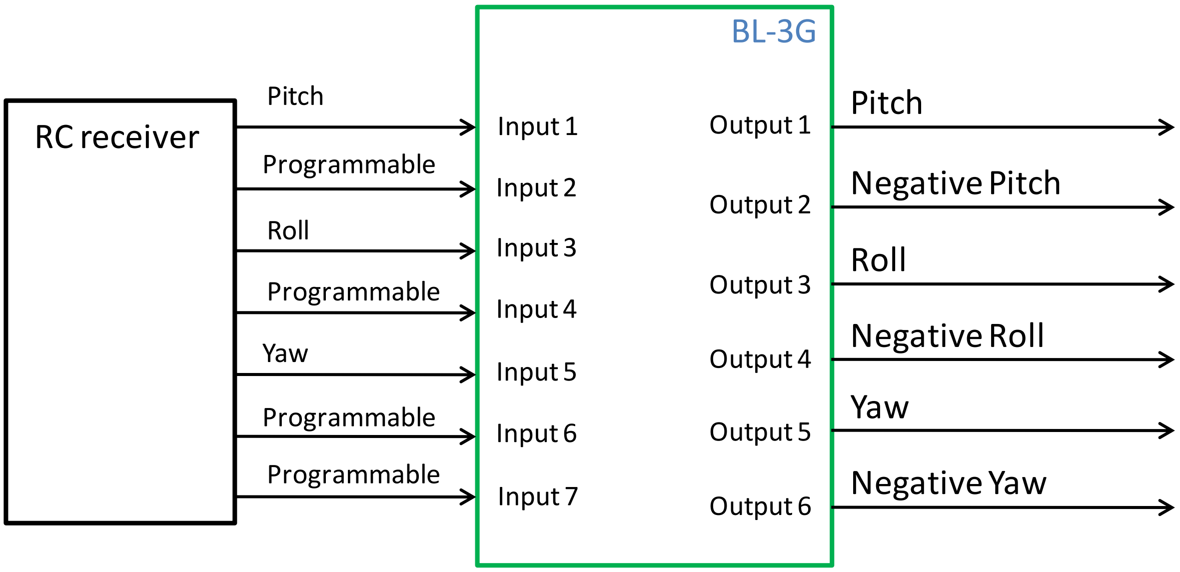
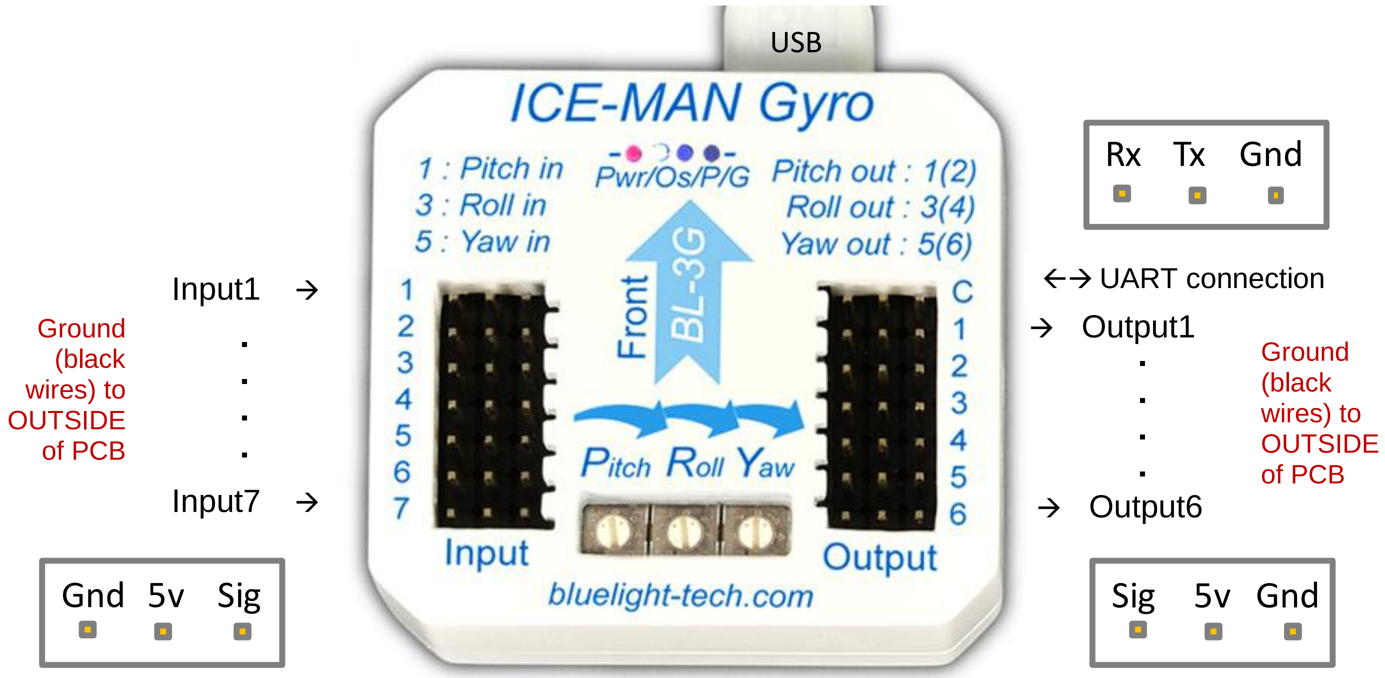
1.0 Introduction and block diagram

The BL-3G gyro has been designed to allow a great deal of fine tuning by the RC model flyer. Gyro control algorithms cannot be perfectly set up for each and every model. Amongst other things, the control algorithm operation depends on the gyro distance relative to the control surfaces, the weight of the model, how much vibration the model generates, how fast the model is flying, etc. etc. On top of this, each flyer will generally have different flight characteristics and performance requirements. Hence the BL-3G comes with a PC set up software that opens up all the important parameters to allow the RC flyer to set things up exactly as required. There are also useful curve, mix, trim and special functions. (As detailed later, there are better ways to trim a gyro equipped aircraft, rather than the normal way with the RC receiver).

The BL-3G gyro block diagram is show below:





Potentiometers (pitch, roll, yaw gain adjust)

With the LEDs indicating the following:

Red (Power on), blue (Software working), red (PC update / Up-side-down mounting), green (Gyro on, or angular rate>10 deg/sec when gyro off).

1.1 Gyro connection to PC

One PC USB-A (male) to mini USB-B (male) cable is supplied:

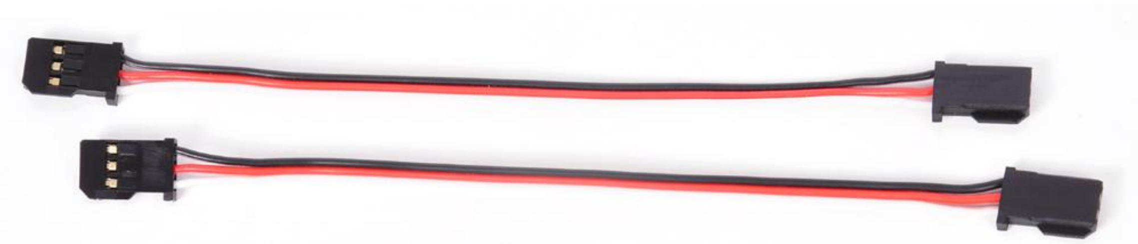
This allows high speed communications between the PC and the BL-3G gyro. It also provides power to the gyro. Note that the USB is limited to drawing 100 mA current from the PC. This is enough to drive the BL-3G gyro and normally also the connected RC receiver. **However an external 5V DC power supply (battery or ESC output) MUST be connected to the unit if servos are also connected at the same time**.

The power can be connected to any input or output (but not the UART pins). Note that during normal flight the gyro will take power from either a separate battery for petrol engine aircraft, of from the electric motor controller for electric flyers. It is most important to make sure the connections are such that the ground wire is always connected to the outside pin of the BL-3G gyro.

Ground pins (black wire) are ALWAYS on the outside of the PCB.

(5V in the centre and the signal on the inside).

Four gold plated contact Futaba J type 3 pin cables (with polarization tabs) are supplied with the BL-3GRC unit (not with the BL-3GMod):



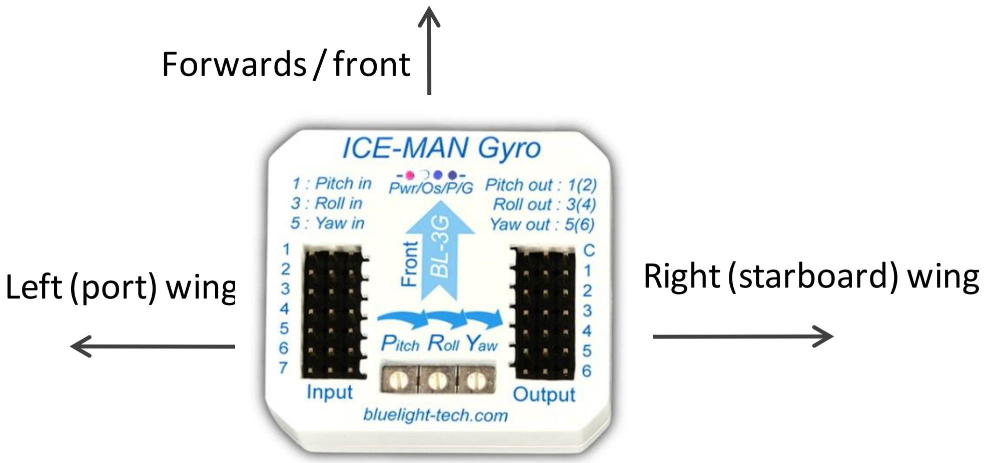
These for connecting the RC receiver outputs to the gyro inputs.

Note that if the cables don't fit into your RC receiver unit then the polarization tabs can be simply cut away.

Note that the unit can be easily operated exactly the same with an RS232 communications cable (not supplied). However a USB connection is first necessary to set up the gyro to operate in this mode. Note that if your PC does not have an RS232 port, then a standard USB to RS232 cable needs to be purchased and the software driver installed onto the PC first.

1.2 Gyro connection to aircraft

The connection and orientation of the gyro must be as shown here:



This will then guarantee the correct operation of the pitch, roll and yaw controls.

Note that positive pitch is defined at an elevator movement resulting in a height gain. Positive roll is defined as an aileron movement resulting in a starboard (to the right) directional change. Positive yaw is defined as a rudder movement resulting in a clockwise (to the right) rotation of the aircraft.

Installation should also be as close as possible to the aircraft centre of gravity.

It is also possible to mount the Gyro **up-side-down**, by either selecting this option in the *Quick Start* tab or the *Basic* tab. In this case the "P" LED on the front of the BL-3G Gyro will illuminate red and extinguish when configuration parameters are sent. (Opposite to normal way round).

1.2.1 Avoiding unwanted vibration

Although the filtering inside the BL-3G is state of the art, it does not hurt to protect further by adding some foam protection between the underside of the gyro and the aircraft base where it is mounted. One method is to use a zeal sheet and tightly affix it to the base of the BL-3G unit prior to installing into the aircraft.

1.3 Gyro electrical installation

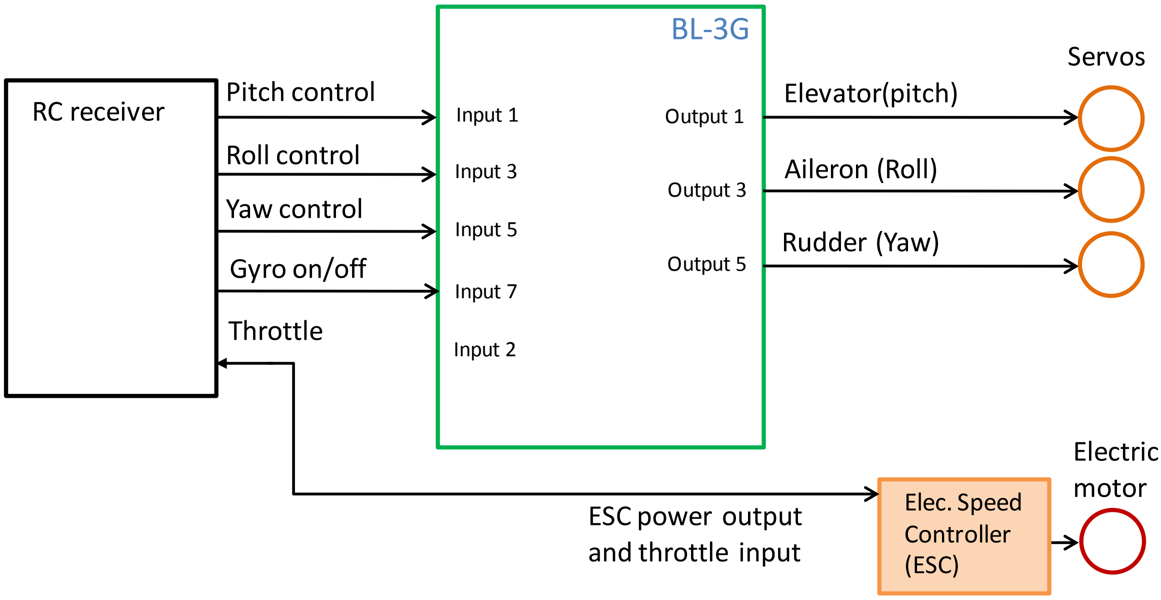
The BL-3G has inputs from an RC receiver and so accepts standard 5v input signals. (These can go up to maximum 7.4v or down to a minimum of 2.2v with no problems).

The BL-3G signal outputs to drive servos and ESC type units have a maximum high output of 3.3v. The power output to the servos / ESC units is directly fed through from whatever battery (normally designated B+), is connected to the gyro. (To either its input pins or its output pins). As shown below, if higher current servos are used then separate gyro / servo power supplies (batteries) must be used. The maximum voltage the gyro can accept for B+ input is 20v, and the absolute maximum current it can pass to its outputs is 3.0 A .

Note that if there is a power interruption (Power outage, or voltage drop below 3.3v) to the BL-3G supply then the BL-3G will operate normally for around 1 second before shutting down or resetting. If the power is re-instated before this time then it will continue to operate normally.

1.3.1 Typical (low power) system connection

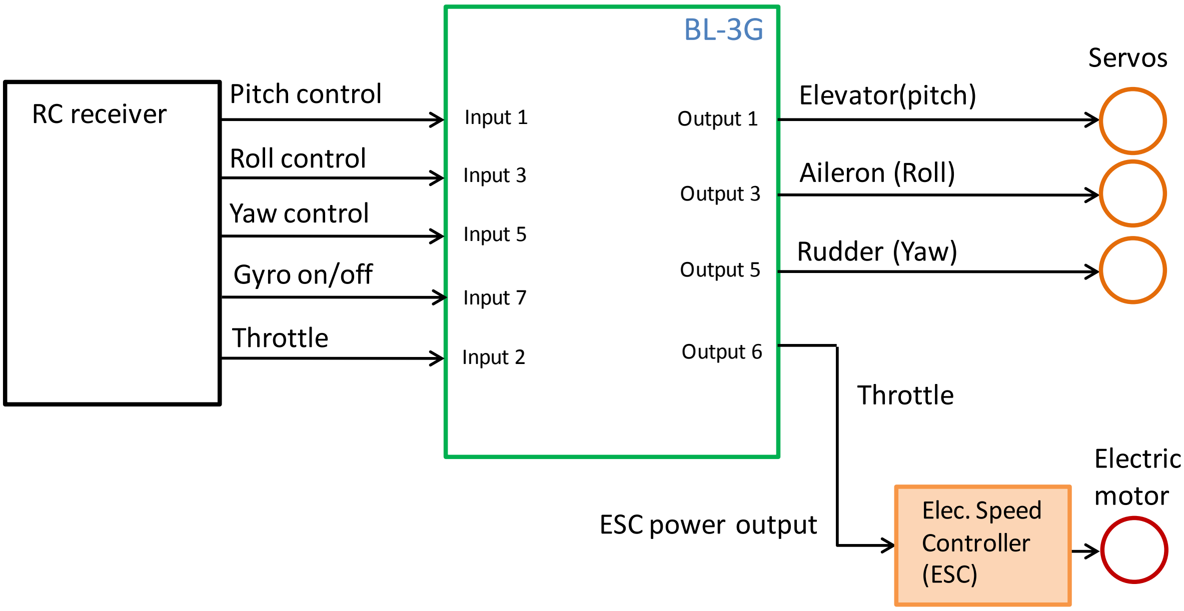
Shown below is a typical system connection:



(This set-up uses the BL-3G default settings).
The ESC provides power to the RC receiver which then provides power to the BL-3G Gyro through its signal wires.

***Note:* The above can be used only if total servo(s) current is less than 2.5A.**

Note the following alternative typical low power connection systems:



(This set-up uses the BL-3G default settings).

In this example the throttle output is taken from the BL-3G output also. The advantage of this method is that the BL-3G can be programmed to have a throttle safety lock feature, and also throttle curve.

***Note:* The above can be used only if total servo(s) current is less than 2.5A.**

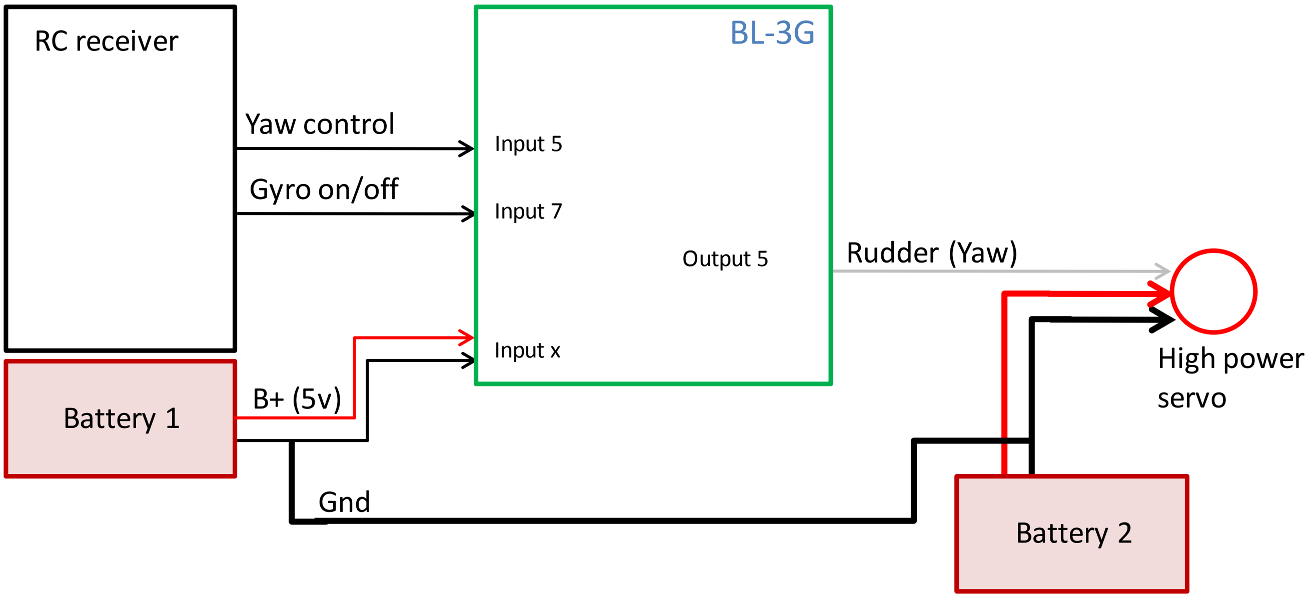
Care must be taken as with any connection method to fully test on the ground first with full power applied to the motor.

Note that some RC cables are sold with the alternative colour coding of yellow/orange, red and brown. These are equivalent to white, red and black as shown here:

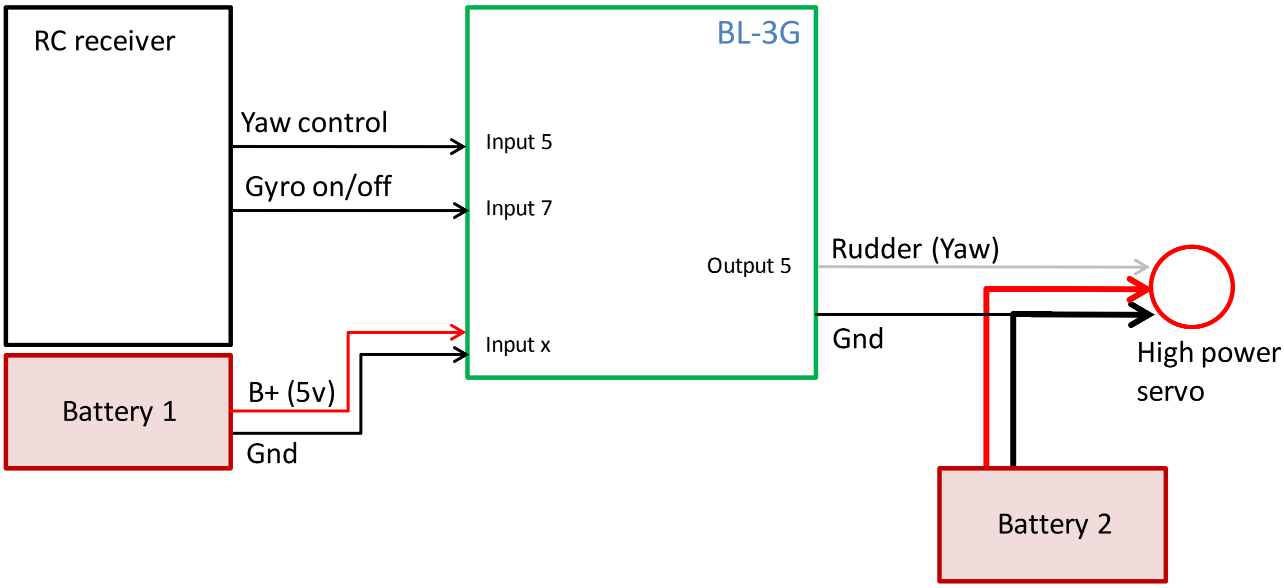
These can be connected together with no problems. It is the RC pilot's responsibility to ensure the connections provide correct and adequate power as required. Please also see the tables in section **1.3.4.**

1.3.2 High current system connection

Shown below is a connection scenario with high current servos (>2.5A total):



The second battery, Battery 2, is now connected to the high power servo. Note that the ground wire to the servo ***must*** also be connected either to the ground of Battery 1 (as shown above), or to one of the gyro ground pins (as shown below), or to both.

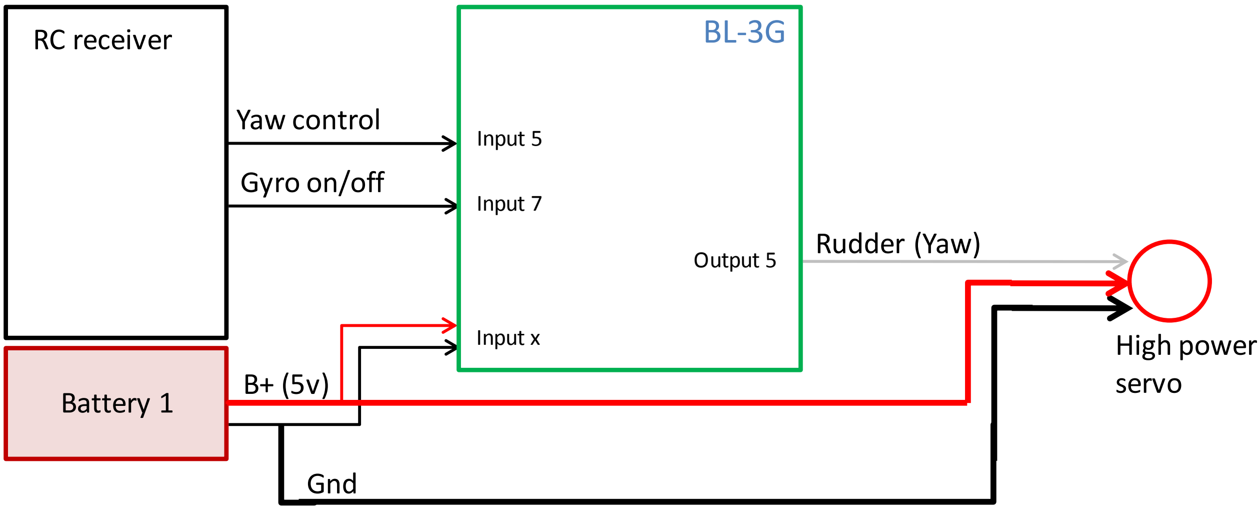


(The above set-ups use the BL-3G default settings).

Note1: If total servo(s) current is 2.5A or more, the servo(s) power MUST be isolated from the BL-3G gyro.

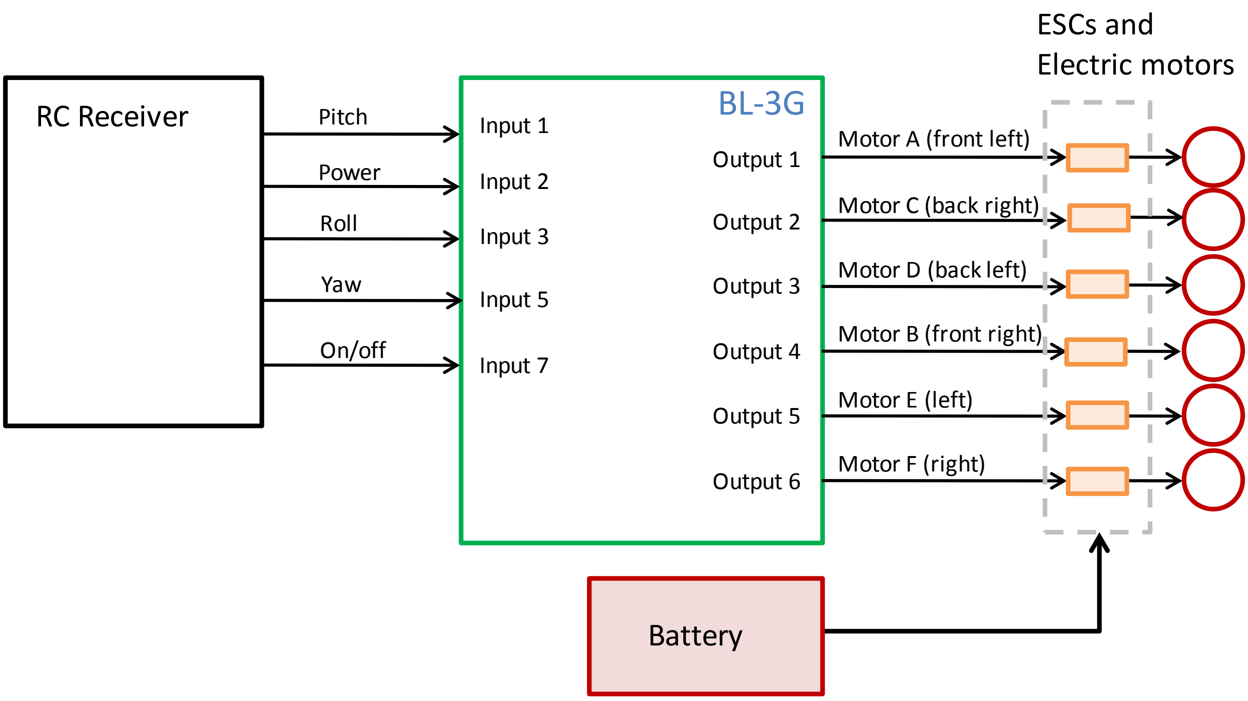
Note2: It is the model flyer's responsibility to ensure the servos get their required power and voltage and to ensure the wires are thick enough to ensure this. (see also below).

If Battery 1 has enough power then it is also acceptable to connect as shown here:



Although good to save the weight and cost of a second battery, the single battery must be of good specification to avoid unwanted noise generation during servo operation. Of course any number of servos can be connected with the methodology of the diagrams above.

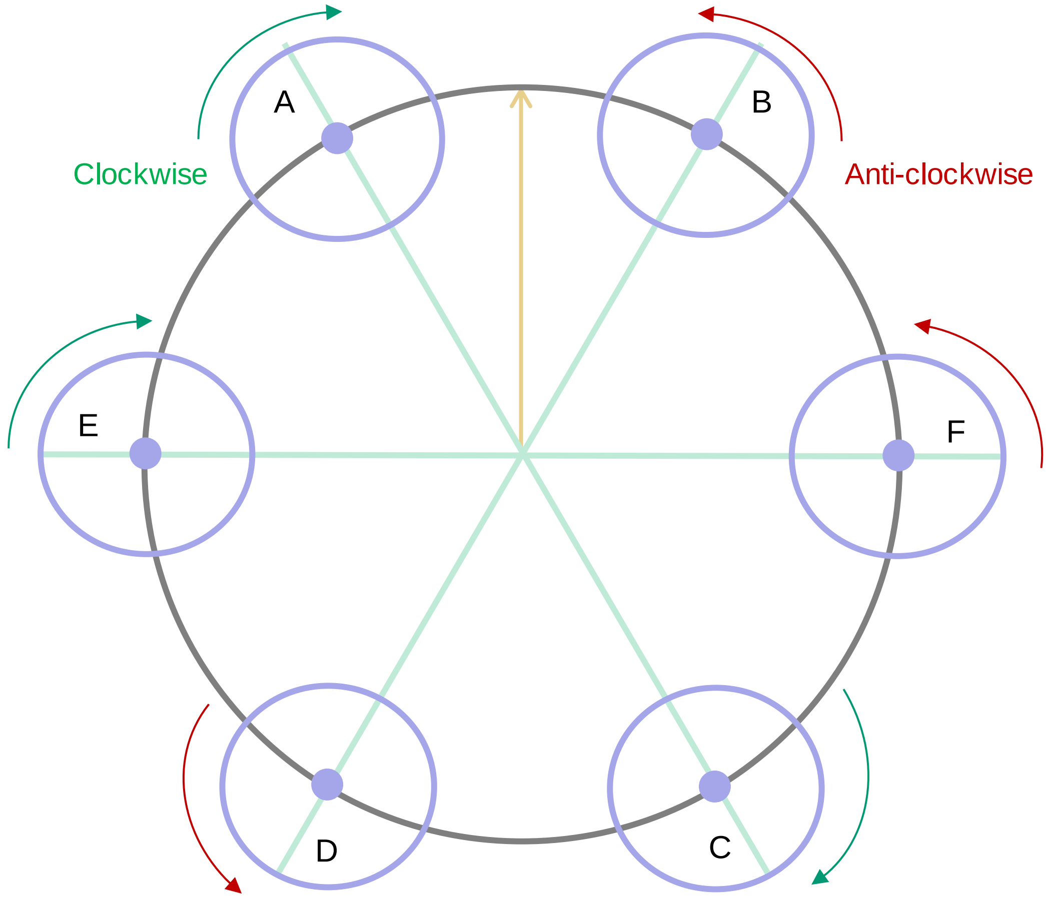
1.3.3 Typical Multi-copter system connection



(The above set-ups use the BL-3G Multi-copter default settings).

The diagram shows a hex-copter, but a quad-copter can be operated by simply not connecting motors E and F on outputs 5 and 6 respectively.

The direction of the propeller rotations must be as shown here. Propeller rotation can be reversed by simply changing the way the Electronic Speed Controller is connected to the brushless / electric motor.



Multi-copter motor and propeller installation

Note1: Quad-copter connections are: A, B, C, D
Note2: Real time switch input for gyro on/off acts as a throttle safety lock in multi-copter mode. See section **2.2.6.1** of this manual.

1.3.4 Cables and Power

It is ***important*** to have sufficiently thick wire (for both ground and power) in order to carry the current required by the servo(s). For information the following table shows the maximum safe current carrying capability for a given wire thickness.

Wire thickness			Transmission current *
AWG	*Diameter in inches*	*Diameter in mm*	*Max current in mA*
28	0.0126	0.3211	228
26	0.0159	0.0405	363
24	0.0201	0.5105	577
22	0.0254	0.6452	918
20	0.0320	0.8128	1,459
18	0.0403	1.0236	2,320
16	0.0508	1.2903	3,690
14	0.0641	1.6281	5,867

It is also ***important*** to meet the servo voltage requirements. The voltage drop at the servo is related to the wire length from the battery to the servo. Some examples:

Distance battery to servo (inch)	**Distance battery to servo (cm)**	**Voltage drop (mV)****	**Voltage drop as % of input voltage (5v)****
12	31	40	0.7 %
36	91	110	2.2 %
48	122	150	3.0 %
60	152	190	3.7 %
72	183	220	4.5 %

** Figures are for: DC 5v input voltage, and Copper wire. ** Figures assume maximum safe current for wire thickness. (If less current is drawn then a lower voltage drop will result).*

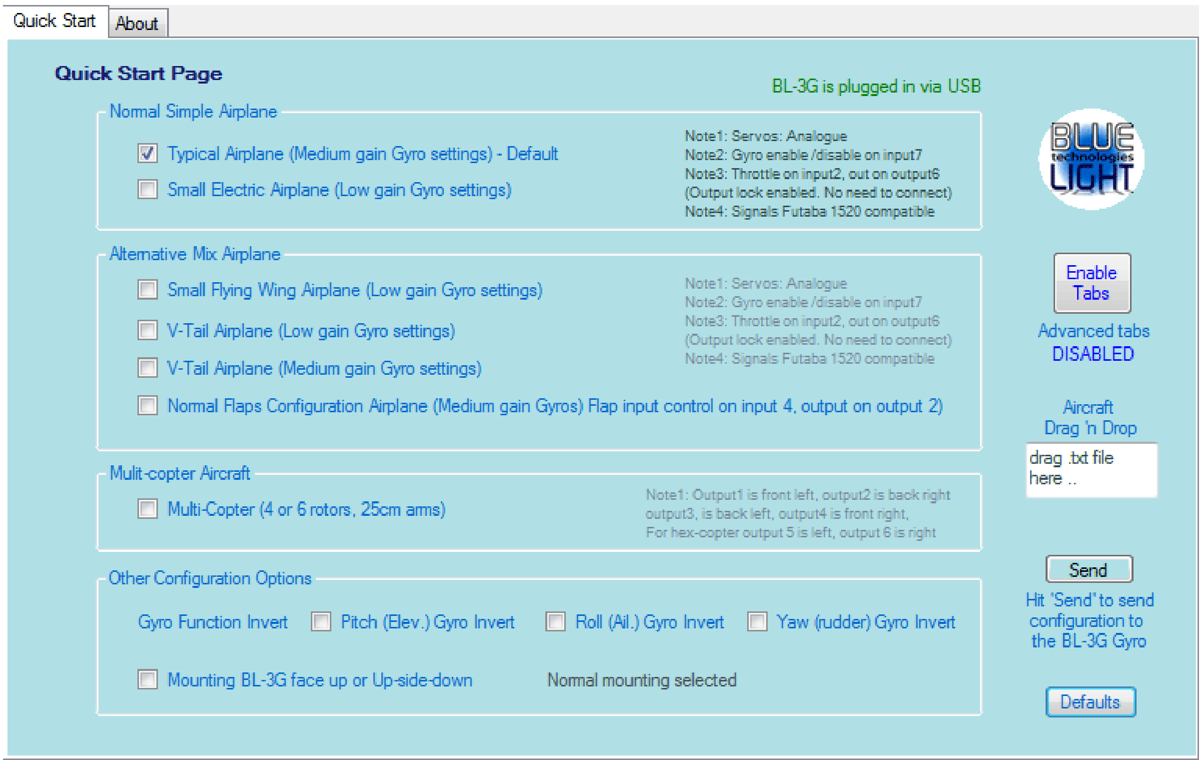
2.0 PC tool and Programmable features

The tool consists of multiple pages used for communicating and setting up the BL-3G gyro. All the following pages will be discussed in detail in this section. The installation procedure is detailed in section **6.0** of this document.

- Quick Start : Standard aircraft configurations and easy loading of script files
- Basic : Inputs / outputs, PID controller gains and mix functions
- Tools : Connection, saving to file, command inputs and visual testing of system
- Mixing : Mixing for non standard aircraft configurations and various flap modes
- Curves : Selection of standard or user defined input curves
- Advanced 1 : Matches up any RC transmitter/receiver to the gyro. Also trim adjustments and control surface range set ups are done here
- Advanced 2 : Real time inputs and features
- Professional 1 : PID controller detailed set up, and sensor only mode selection
- Professional 2 : Kalman, averaging and High pass filtering, Gyro lock features, and zero calibration
- Information : System level diagram to confirm set up / configuration
- Live Data : Analysis of actual data (Oscilloscope mode)
- Upgrade : Firmware upgrade and features upgrade options
- About : Details of Bluelight Technologies and where to check for software updates.

2.1 Tab *Quick Start*: Standard Aircraft Types

This is the first page and contains and allows very fast parameter selection and sending options.



A list of standard aircraft types is given to allow all relevant parameters for such aircraft to be populated onto the advanced tab pages. Initially the advanced modification tabs are hidden, but can be accessed by pressing the *Enable Tabs* button to the right hand side. Below this button there is an Aircraft *Drop n Drag* box. Any standard configuration (.txt) files can be dropped into this box and populate the other tabs accordingly. (A later tools tab will allow such files to be created). Such files can also be shared with others and downloaded from Bluelight website. It is important that when a selection is made that the *Send* button is pressed to send all the set up parameters to the BL-3G Gyro.

The last section on this page allows the gyro function to be inverted and for Gyro up-side-down mounting. More on this below.

The BL-3G *"ICE-MAN"* Gyro is designed to work right out of the box with no further set up necessary with the exception of fine gain adjustments with the supplied screw-driver. A Quick set up procedure will be described here for users who don't want to use the PC set up software, with comments for those who wish to do some basic modifications with the PC set up software.

2.1.1 Quick *"Out of the box"* installation for fixed wing aircraft

- **1:** Ensure all servos and aircraft control surfaces are working as expected **without** the BL-3G Gyro installed

- **2:** Connect up the BL-3G Gyro between the RC receiver unit and the aircraft servos. All RC receiver outputs should be connected to the BL-3G Gyro inputs as shown here (make sure the BL-3G Gyro is **not** connected to a PC):

Rx Elevator	->	BL-3G input 1 (Pitch)
Rx Aileron	->	BL-3G input 3 (Roll)
Rx Rudder	->	BL-3G input 5 (Yaw)
Rx Channel5	->	BL-3G input 7 (Optional, Gyro on/off)

  No need to connect the throttle signal at this time.

  See diagrams in section **1.3** for physical connections

- **3:** Connect the BL-3G outputs to the aircraft control surfaces as detailed here:

BL-3G output 1 (Pitch)	->	Elevator servo
BL-3G output 3 (Roll)	->	Aileron servo
BL-3G output 5 (yaw)	->	Rudder servo

- **4:** Now, being careful to make sure your **RC Tx is switched ON** and with the **throttle at the minimum** position, connect the throttle signal from the Rx Tx to either the BL-3G input 2 or to the ESC unit throttle connection.

- **5:** Wait until the BL-3G Gyro blue and yellow lights start flashing**,** then make sure the aircraft ailerons, elevators and rudder move as expected when you activate your RC Tx control sticks.

- **6:** Make sure your control surfaces still move in the required directions as you activate your RC Tx sticks. If any move in the wrong direction, then you can instead connect the servo to the inverted signal out. E.g. if your elevator is incorrect you can move the connection to the elevator servo onto BL-3G output 2 instead of Output 1. Alternatively you can move the slider switch on your RC Tx to invert the signal. (Alternatively if the input signal can be inverted with the PC set up software).

- **7:** Pick up the aircraft and move it around in all three axes to check if the gyro function is as expected. I.e. if you make a sharp move in a particular direction, the gyro function should activate the control surface in such a way as to combat the sharp movement.

- **8.** If the gyro function is in the opposite way than expected then for whichever control surface or surfaces are incorrect you will need to follow the procedure here:

Incorrect Elevator Gyro function:

Activate the RC Tx elevator slider switch (if you have one) on your RC tx to invert the signal**.** Now connect the elevator servo to BL-3G **output 2** instead of output 1. (Or output 1 instead of 2 if you have it swapped).

Incorrect Aileron Gyro function:

Activate the RC Tx aileron slider switch (if you have one) on your RC tx to invert the signal**.** Now connect the aileron servo to BL-3G **output 4** instead of output 3. (Or output 3 instead of 4 if you have it swapped).

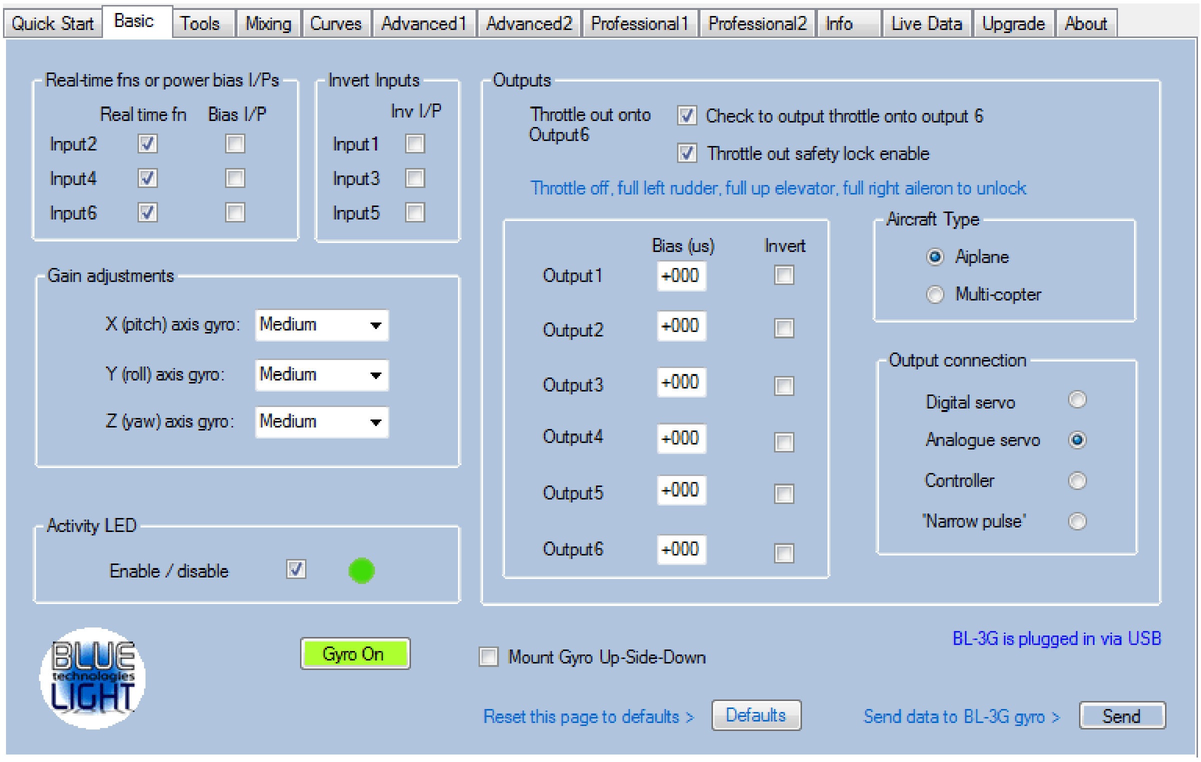
Incorrect Rudder Gyro function:

Activate the RC Tx rudder slider switch (if you have one) on your RC tx to invert the signal**.** Now connect the rudder servo to BL-3G **output 6** instead of output 5. (Or output 5 instead of 6 if you have it swapped).

The alternative to the above is to use the BL-3G set up software and invert the inputs from the *Basic* tab page instead (You will still need to use the alternative outputs), or if you prefer, to invert the gyro function itself from either the *Quick Start* tab page or the *Advanced 1* tab page. (In this case no need to use the alternative outputs). Before doing this, i.e. before connecting the BL-3G Gyro to the PC via USB, make sure to have power applied to the BL-3G Gyro from your aircraft system. Alternatively disconnect the servo outputs from the BL-3G Gyro before connecting the BL-3G Gyro to the PC and re-connect the outputs after re-programming is complete and the Gyro disconnected from the PC.

2.2 Tab *Basic*: Basic operational modifications

This is the first page and contains basic modifications as detailed here. At the bottom of the page there are two buttons:
'Default' button: This sets the page to its factory default values.
'Send' button: This sends the data from all pages to the BL-3G. Note that this button must be pressed otherwise all data on the BL-3G will be lost when it is powered off.



2.2.1 Real-time functions or power bias inputs

Generally the Input1, Input3, and Input5 will be used for Pitch, Roll and Yaw inputs respectively, as shown on the block diagram of the introduction. This leaves Input2, Input4, Input6 and Input7 for either real time inputs, i.e. special functions that can be activated with spare channels on an RC transmitter, or as power bias inputs (for multi rotor applications). The special functions will be covered in detail under the *advanced 2* tab section of this manual. They are active if checked in this *basic* tab section.

2.2.2 Input Invert

These check boxes allow the input signals for the Pitch, Roll and Yaw to be inverted. Note that the bars on the *Advanced 1* tab page will not change direction, since they represent the actual input from the RC transmitter.

2.2.3 Gain adjustments

These adjustments basically define how much of an effect the gyro function has. Gain adjustments for the pitch (X), roll (Y) and yaw (Z) axes PID controllers are set here to be either 'low', 'medium' or 'high'. (The actual values set can be seen under the *professional 1* tab). By default they are all set to Medium gain.

2.2.4 Active rate LED

A green LED is set to illuminate as follows:

When Gyro off (disabled): When the rate detected on any axis is equal to or greater than 10 dps.

When Gyro on (enabled): Continuous intermittent flashing.

The LED can be disabled for whatever reason such as to save a little power.

2.2.5 Gyro On/Off switch

The switch is provided in case it is required to switch the gyro off at all times. In which case the BL-3G can be used simply as a mixing unit. (It can also be useful during the *Control Surface Range* set up procedure as explained in section **2.6.3**).

2.2.6 Outputs

The outputs can be set to *normal* meaning, Output1 will be the pitch output for the elevator control, Output3 will be the roll output for the aileron control, and Output5 will be the yaw output for the rudder control. The Output2, Output4, and Output6 are just the 'inverted' versions of the above signals respectively.

Power out onto Output6: This option allows a throttle signal input on any of the inputs (must be set up from the *Advanced 2* tab page), to be output onto Output6. This can be useful since a special power curve can be set up (see section **2.5**) prior to the signal driving the motor controller. It is also useful to have the Throttle lock safety feature as detailed next.

2.2.6.1 Throttle Safety Lock

When the power (throttle) signal is programmed to be output onto output6, the output is at the minimum level (i.e. throttle off) until it is unlocked. To unlock the following stick positions need to be momentarily performed:

Throttle	: Full low
Yaw (rudder)	: Full left (low)
Pitch (elevator)	: Full up (high)
Roll (ailerons)	: Full right (high)

Note that the positions of the sticks may vary depending on individual combinations of different RC transmitter input signals and input signal invert settings. To achieve exactly the same as shown in the diagram above you need to do the following:

- **1:** Go to the *Advanced 1* page tab, and check which way your control surfaces are set up. Hit the ***Active*** button, and if the following happens:
  - (i) The Pitch bar moves to the down side as you move your RC Tx pitch lever up

(ii) The Roll bar moves to the right as you move your RC Tx roll lever to the right.
(iii) The Yaw bar moves to the left as you move your RC Tx yaw lever to the left
(Go ahead and hit the ***Cancel*** button when done)

And you have no ticks in the *Invert Inputs* check boxes on the *Basic* tab page then the throttle lock will operate as shown in the diagram above.

- **2:** If any of your inputs are contrary to the above, then simply invert them on your RC Tx unit, ***or*** tick the appropriate boxes in the *Invert Inputs* check boxes on the *Basic* tab page. (Ticking the *Invert Inputs* check boxes will not change the motion of the bars on the *Advanced1* tab, but will ensure your throttle lock is as shown in the diagram above).

In Multi-copter mode the rotor outputs will be locked until the Gyro on/off switch is switched to the on position. In Multi-copter mode it is therefore important to make sure the switch is selected to the Gyro off position to start with. This can be achieved knowing the RC transmitter operation and checked prior to connecting the BL-3G Gyro to the multi-copter. The yellow LED light will NOT blink when the Gyro is in the off mode.

Take care. Immediately after performing the unlock procedure, since the ***throttle will be active*** and follow your RC throttle stick (optionally modified by a throttle curve if selected on the *curves* tab page). ***If the throttle lock feature is not selected, the throttle will always be active.***

2.2.7 Outputs – Bias and invert

Each output can be programmed to have a positive or negative DC bias added to it. Each signal can also be inverted. This may be useful since for each axis (pitch, roll and yaw) a positive signal is supplied on the odd Output pins and the inverse on the even Output pins. If, for example, an aircraft with two servos for the ailerons, requires that both servos get the same signal then one can be inverted (either Output3 or Output4 in this case).

2.2.7.1 Stall softener feature (Differential Ailerons)

If you have separate servos for the wings it's possible to add some bias to both servos to allow them both to deflect up more than down. This helps to reduce the likelihood of a wing tip stall when aileron deflections are made at high angles of attack.

2.2.8 Outputs – Aircraft Type

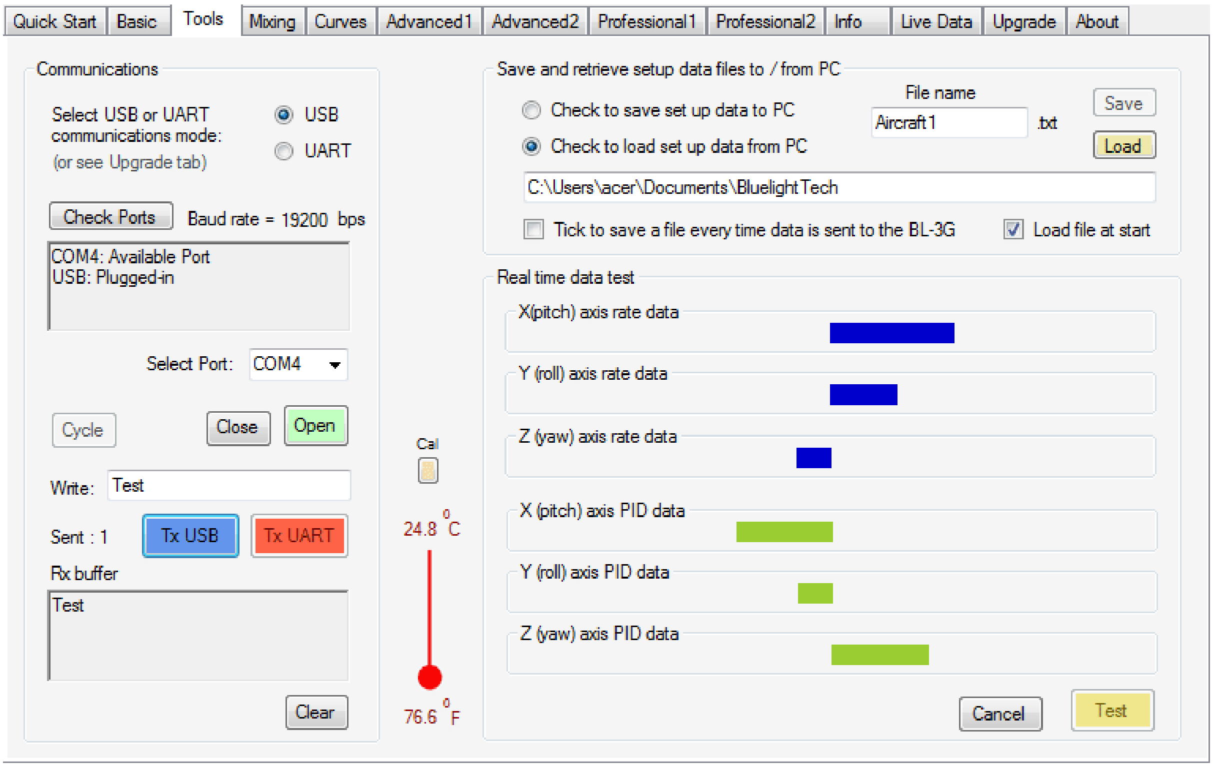
If no inputs are supplied, the BL-3G will generate its own carrier signal pulses to use as inputs. The pulse width is thus specified here. For airplane applications this must be set to the mid range. (For multi-copter applications this must be set to minimum, since no inputs generally means no power should be applied to the rotors). The selection also ensures up to six motors are supported for multi-copters, and normal control surfaces for airplanes.

2.2.9 Outputs – Output connection

The outputs can be set up to drive either standard type (digital or analogue) servos or motor controllers or non standard so called ‘narrow pulse’ servos. See section **5.0** for more information. Note that these settings will be inaccessible if the outputs are modified on the *advanced* tab page.

2.3 Tab *Tools*: Programming and testing

The tools page has various tools available to both program and test the BL-3G gyro.



2.3.1 Communications

This section allows the PC to connect to make sure communications with the BL-3G are ok. It also allows test commands to be sent to the unit and the responses seen.

The above example shows that COM4 is available. This means the serial USB cable driver has been successfully installed and the cable connected. (But not necessarily yet the BL-3G to the other end of the cable). On pressing the green *open* button the selected port (in this example COM4) is connected to. An error message will display if the connection fails. If all is ok then the test word 'Test' can be written into the *write* window. On pressing the red *Tx* (transmit) button an echo of the word should appear in the Rx buffer window. If it does not appear an error message will be displayed instead. The echo means the BL-3G has successfully received the word and has echoed it back again.

The write window can be used to write a number of commands to the BL-3G. Details of this are available in the systems developer document. See section **4.0** for details on the commands available.

The *Cycle* button is used to cycle through the various baud rates. This option is available in case the BL-3G baud rate was previously changed and forgotten about. This option is available only when a port is open and will set the software to the correct baud rate. Note that for the BL-3G gyro the baud rate is currently fixed at 19,200 b/s.

2.3.2 File save and read back options

It is possible to save a file onto the PC hard drive (or connected memory) for future reference with a user defined path and file name for the file. It is also possible to set up the software so that each time the *send* button on the *Basic tab* page is pressed, the file is also saved. These features allow a file to be saved for each aircraft used and so the settings can then be re-used to program the gyro in future for the particular aircraft. The file saved is a simple text file and so can be carefully edited to change aircraft information if required. Any file can also be read back into the PC set up software for immediate download to the BL-3G gyro, or for some changes to be made based on it prior to download to the gyro. *The Load file at start* option allows a file to be automatically uploaded into the BL-3G set up tool at start up of the tool. In this way a previous file that you may have been working on is automatically loaded in at the start.

2.3.3 Real time data test

This section allows for the acquisition and graphical display of the gyro X (pitch), Y (roll) and Z (yaw) rate data. This testing can be enabled and disabled with the buttons provided. The gyro positive and negative rates are shown in blue colour.

The lower display in green colour shows the positive and negative PID outputs. This is the control signal that is output to the aircraft.

In the example above there is positive angular acceleration about the X and Y axes and negative about the Z axis (Blue colour). This means the aircraft has sustained both a positive pitch and a positive roll rotation. To counter this, the output signals (green colour) are showing commanded movement of the aircraft control surfaces to counter these disturbances.

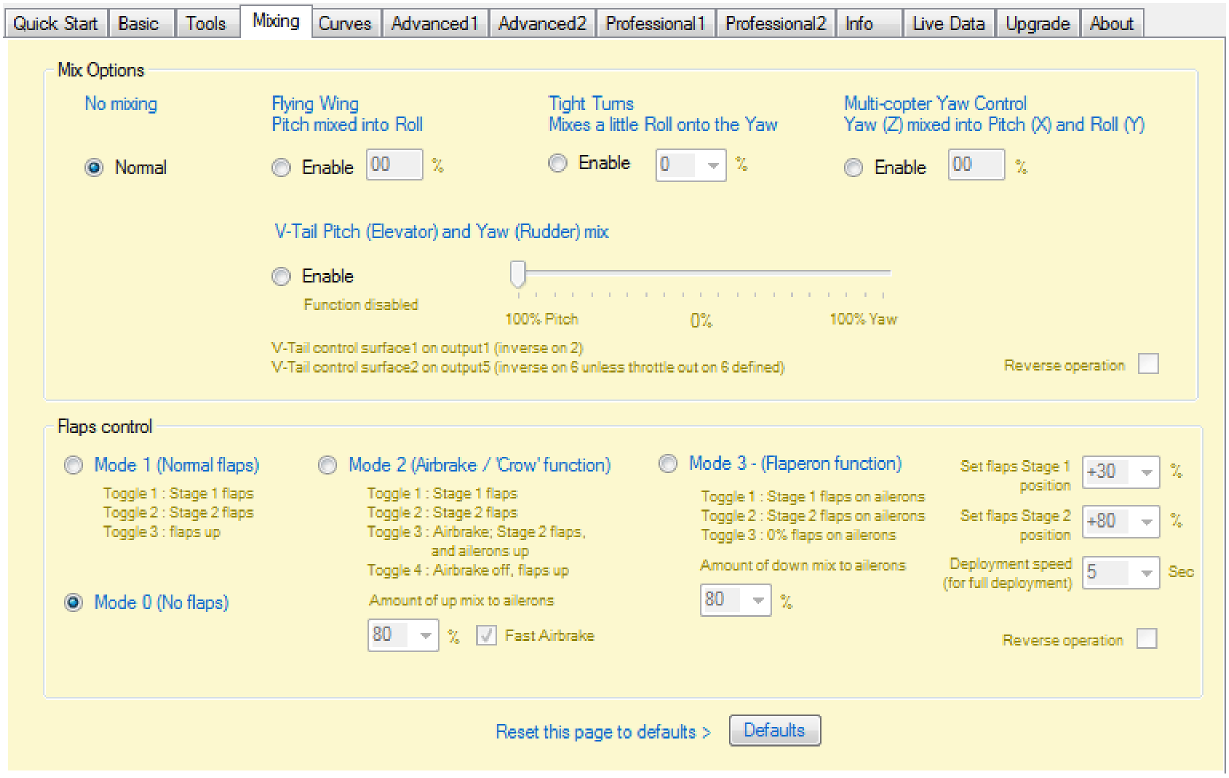
These graphical displays are also used to set up the aircraft pitch and control surface ranges as detailed in section **2.6**).

2.3.4 Temperature

The temperature is also shown on this page. It is updated when the thermometer icon is pressed, provided the connection is still established and the real time data acquisition function (*real time data test)* is not active. The data returned is 32 second averaged data. (Note that if the temperature data is requested prior to waiting 32 seconds the 0 degrees C will be displayed). The ST gyro MEMs chip has a temperature sensor inside in order to realize the ultra stable performance of the device. It is only displayed on this page for interest. For best results press the *Cal* button and enter the current room temperature (once at least after purchasing the BL-3G gyro).

2.4 Tab *Mixing*: Non standard aircraft configurations and flaps

This page allows for Flying wing, V-tail and Multi copter mix functions to be programmed.
The *'Default'* button sets the page to its factory default values.



2.4.1 Mix Options

Five different modes can be selected.

Flying Wing mode:

Pitch mixed into Roll: This option allows for a flying wing type aircraft to be supported. This is an aircraft type with no separate pitch control. Hence the ailerons must support both pitch and roll. When this option is selected Output3 and Output4 are used as the outputs for the two flying wing servos. When enabled it is possible to set the % of mixing required. (Flaperon function below can also be used in this configuration).

Tight Turns mode:

Some Roll signal mixed into the Yaw: This allows a small percentage of the input roll signal to be mixed into the Yaw for the rudder.

Multi-copter mode:

Yaw (Z) mixed into Pitch (X) and Roll (Y): This option is used for multi-copter applications where the yaw control must modify the RPM of each of the central four motors.
(Thrust on two to be increased and thrust on two to be decreased. This coupled with the rotational direction of the motors gives the yaw control). When enabled it is possible to set the % of mixing required.

V-Tail mode:

Pitch (Elevator) and Yaw (Rudder) mix: A slide is supplied to adjust exactly how much pitch is used and how much yaw is used to output. When enabled one V-Tail servo output is given on output1 and an inverted version on output2. The second V-Tail servo is given on output2 with an inverted version on output6, unless output6 has been set to output the throttle signal.

Note that the ***Reverse operation*** box can be ticked if necessary for your particular configuration. If this is ticked then the application of the particular mix function is reversed. E.g. if you have the flying wing selected and when you roll the aileron function is the wrong way round, you can invert it by ticking this box.

2.4.2 Flap Modes

Four different flap modes are supported. For aircraft with actual flaps the flap input control is selected to be any of the spare inputs to the BL-3G Gyro via the *Advanced 2* tab page. The flaps output signal is then given on **output 2**.

The input flap signal will operate as a toggle switch thus allowing a simple RC transmitter with a two way switch to perform the control. A transition from low signal to high signal acts as the active toggle switch.

Mode 1 (Normal): In this mode when the input is switched on and off again the flaps will move to a "Stage1" position. The "Stage1" position is set up in the *Set flaps Stage 1 position* box to the right hand side of the tab. When the switch is again activated low then high again the flaps will move to the "Stage 2 position". The "Stage 2" position is set up in the *Set flaps Stage 2 position* box. The settings in these boxes are a percentage of the half stick range (typically about 500 µs). The speed at which the flaps are deployed is set up in the *Deployment speed* box. This time, in seconds, is the length of time it would take the flaps to move their full range (i.e. from flaps off to flaps fully extended). On the third toggle of the switch the flaps will return to their home position.

Note that if a bias input is added from the *Basic* tab page then this will also appear on the flap output signal. An output *Invert* programmed in from the *Basic* tab page will also invert the operation of the flaps.

Mode 2 (Airbrake / 'Crow' function): The performance of this mode is the same as the *Normal* mode described above, with the following differences: A toggle (switch up then down) when the flaps are at their Stage 2 deployment position will result in the flaps staying there and instead both ailerons will move to a certain up orientation. This to act as an airbrake. While the ailerons move up they will still act as ailerons. How far

extended they become is set up in *the Amount of up mix to ailerons* box. The speed at which these actions happen is the same as for the *normal* flaps mode, however a tick box is provided to have the ailerons deployed (activated and also retracted) much more quickly. This box performs 100% deployment is 2 seconds.

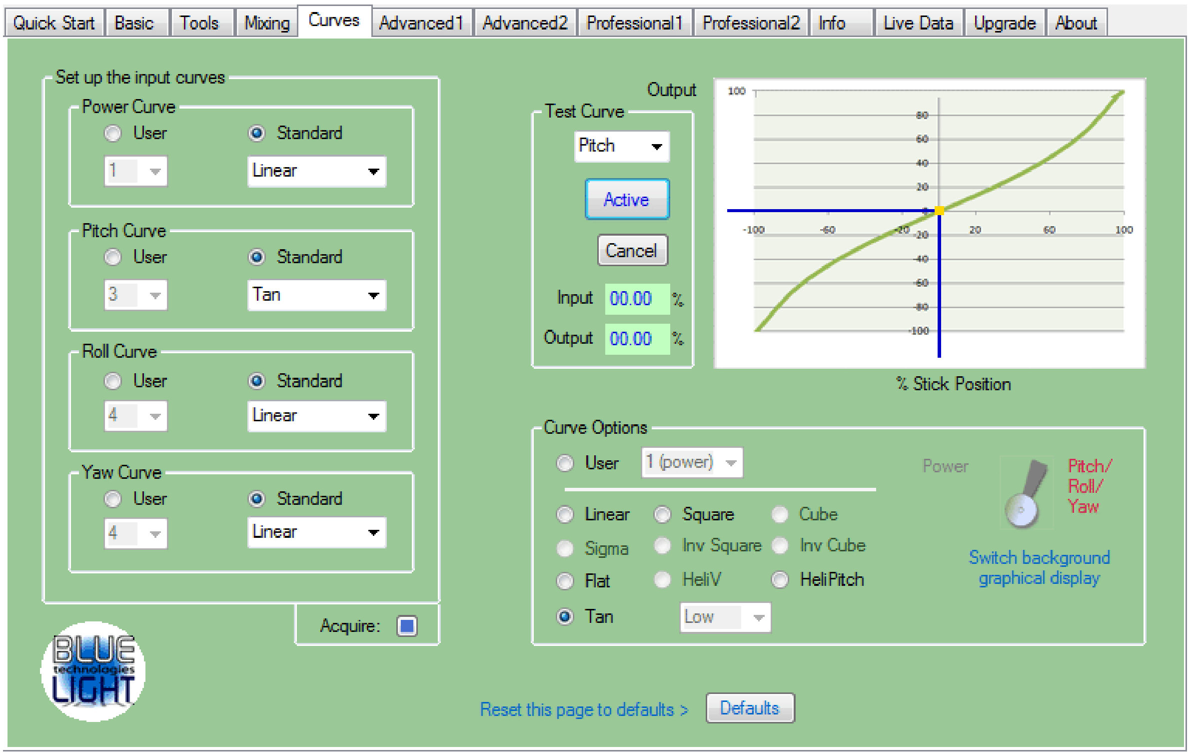
Mode 3 (Flaperons): For aircraft with no actual flaps the flap function is added to the ailerons in this mode. The operation is similar to normal flaps mode, but this time the signal is added to the ailerons. An *Amount of down mix to ailerons* box is provided to further modulate the amount of down mix added. This percentage acts on top of the *Set flaps Stage 1 position* and *Set flaps Stage 2 position* boxes.

Deployment Speed zero set: In modes 1 and 2 it is possible to set a zero value into the *Deployment Speed* box. In this mode the flaps input signal coming in on one of the pre-programmed BL-3G inputs will be passed through directly to the flaps output (output2). This then allows an exact flap control based on an RC Transmitter setting.

Note that the ***Reverse operation*** box can be ticked if necessary for your particular configuration. If this is ticked then the application of the particular flap function is reversed. E.g. if you have mode 1 flaps selected and when you toggle the flaps switch your flaps go up instead of down, then you can correct it by ticking this box.

2.5 Tab *Curves*: Input curve set up

This page sets up the input control curves. The *Set up input curves* section on the left details what is to be programmed into the BL-3G gyro. The other sections of this page are tools to either generate user curves or to aid in selecting the correct curves to use. The *'Default'* button sets the page to its factory default values.



2.5.1 Set up

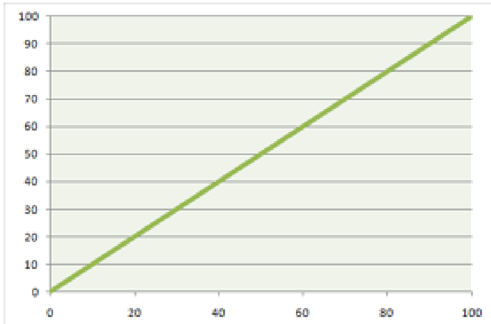
Looking at the left hand side set up section; for each of the axes (power, pitch, roll, yaw) either a user defined curve can be selected, or a standard one. If a standard one then the options are given in the pull down menu. The tools described below will aid in making the selection.

2.5.2 Curve Options

A switch on the right hand side of this section allows for the background graph (above) to be changed depending if the input of interest is a power curve or a pitch, roll or yaw (PRY) curve. This section then allows for the various standard curves to be seen. For example the picture above shows a *Tan* (Tangent) curve has been selected and so is shown in the graph area on top of a PRY background. I.e. the stick is shown going from -100% to +100% with corresponding output also from -100% to +100%. If a power curve were selected then the background graph would show the curve on top of a graph as shown here.

Power graph with stick input from 0 to 100% and corresponding output also from 0 to 100%

Output

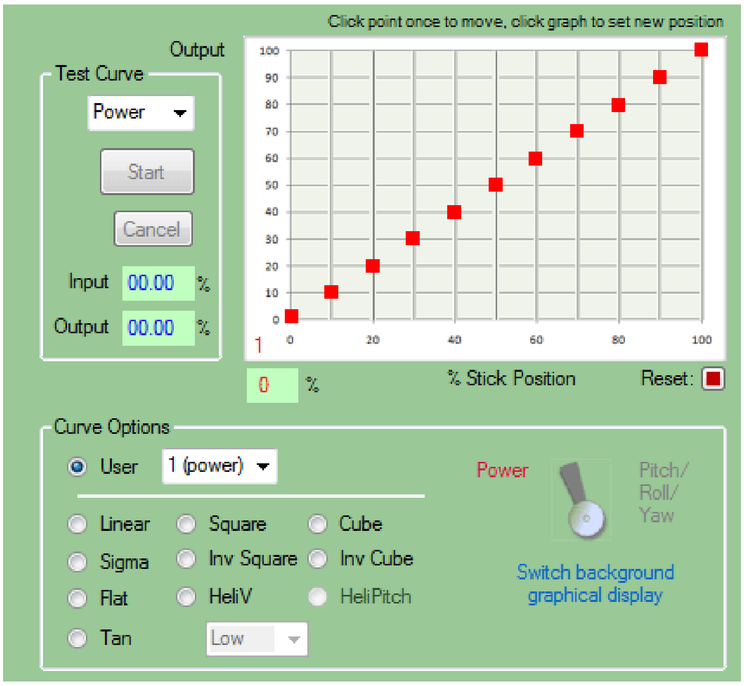


Stick position

The purpose of this section is to allow the curves to be seen such that the curve required can then be input in the *Set up input curves* section to the left. It is also possible to create user own curves as detailed below.

2.5.2.1 User Curves

By selecting the *User* option, two power curves can be generated and also two PRY curves. The following display is seen when the user option is first selected:



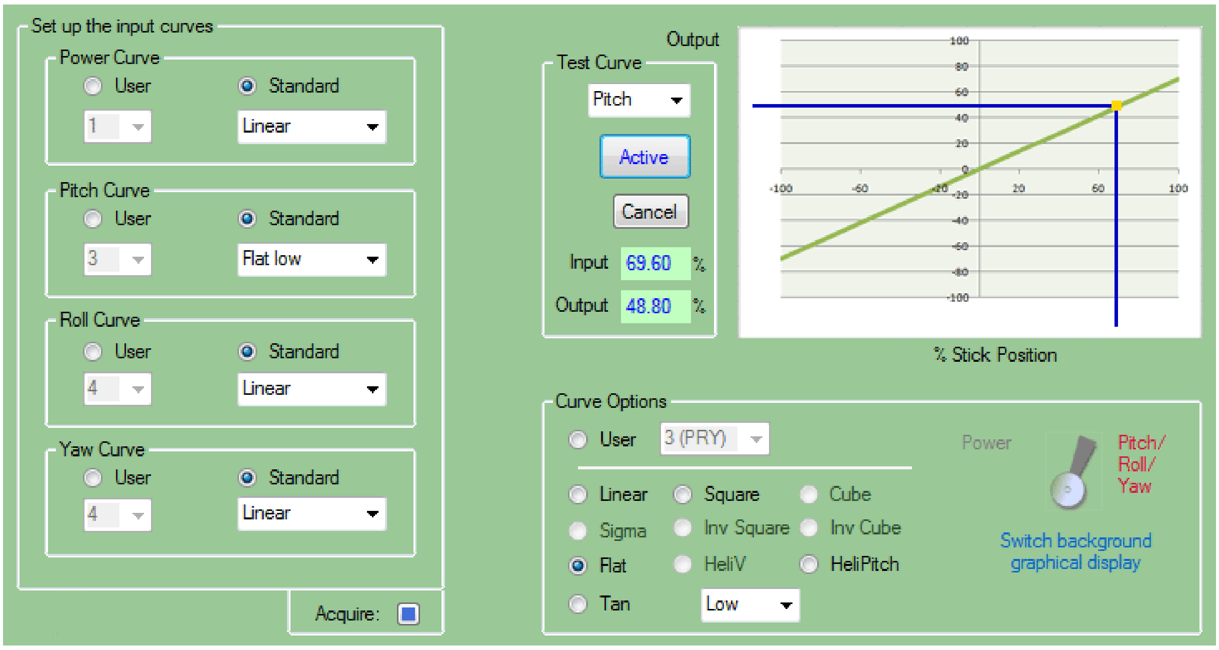
A red dot is simply clicked on once (click and release), then moved to the desired location (vertically). A further click (click and release) away from the dot itself then fixes the dot in the new location. In this way a unique user curve can be set up. For information the green box, with red numbers, underneath the graph will show the exact location the dot is being moved to. If you wish to re-start the construction process for a specific curve then the red *reset* button can be pressed at any time to recover the linear curve.

The curves are automatically saved (to PC memory) as they are constructed. However, in order to save the curves into the BL-3G gyro the *Send* button on the *basic* tab page must be pressed.

2.5.3 Test Curve

This section allows a curve to be tested to make sure it is working correctly. The test uses the real RC transmitter input signal and so is the actual curve within the gyro that is being tested. For example, let's assume that a *Flat low* curve is required for the pitch curve. In order to test this inside the gyro the following procedure is performed:

- **1:** *Standard* and also *Flat low* are selected for the *Pitch Curve* in *the Set up the input curves* section.
- **2:** *Pitch* is selected as the axis of interest in the *Test Curve* section
- **3:** *Pitch / Roll / Yaw* is selected with the lever switch in the *Curve display Options* section
- **4:** *Flat* is selected in the *Curve display options* section as well as *Low* from the pull down menu.
- **5:** The *Start* button is now pressed inside the *Test Curve* section. (Note that this action actually temporarily programs the gyro with the new curve).
- **6:** The RC Transmitter is switched on and the pitch lever activated.



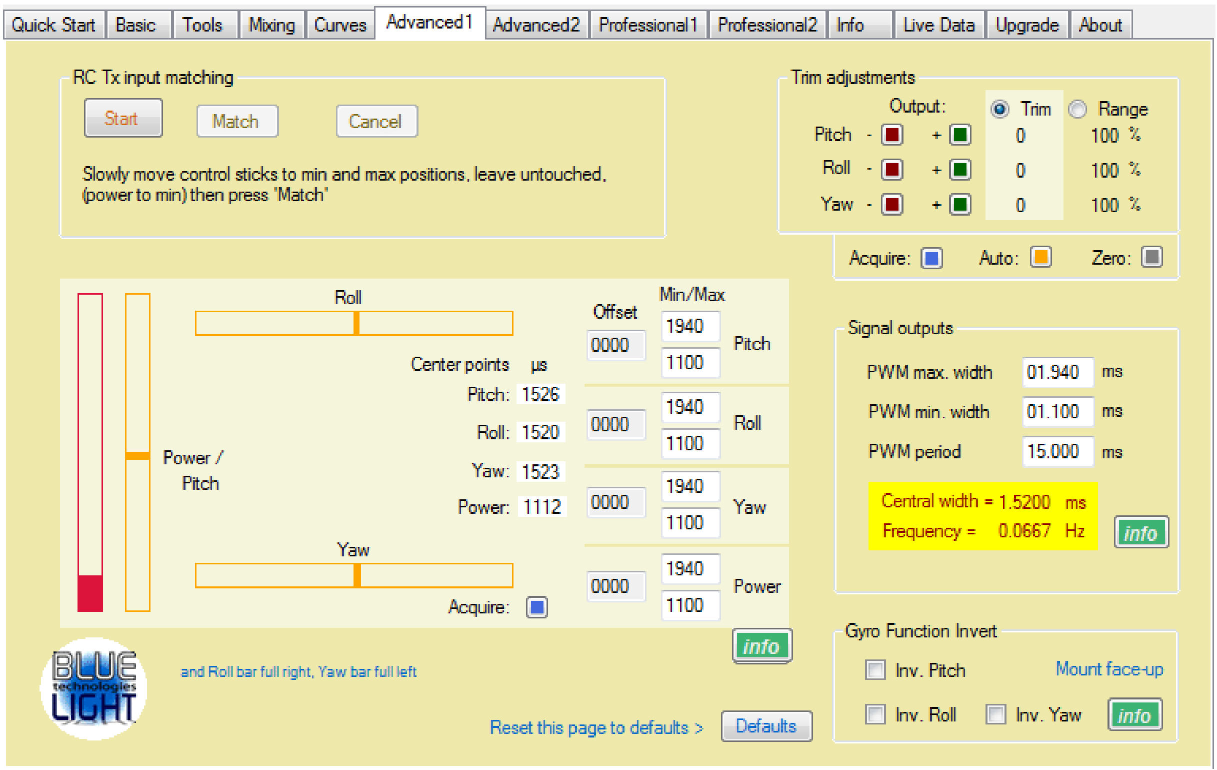
A yellow dot will appear with blue horizontal and vertical lines extending from it. These will move as the pitch lever is activated. The new output (horizontal line) will now be used by the gyro instead of the normal input (vertical line). For interest numerical values of input and output are also shown in the green boxes to the left of the graph. Note that all the standard curves are mathematically calculated and so the conversion from the stick position to the actual output used are 100% smooth. For the user generated curves linear interpolation is performed from the 11user input points. The user curves can also be tested with the *Test Curve* tool.

Note that if the motion of the yellow dot doesn't extend through the complete range (-100% to +100%) then the procedures of section **2.6.1** will need to be performed.

Once the curves have been selected and the *Set up the input curves* section completed, the *send* button on the *basic* page tab must be pressed in order to send all the data to the BL-3G gyro memory. Note that the blue *Acquire* button can be pressed in order to acquire the data stored in the BL-3G gyro if required. This will retrieve all the curves data including the 4 user curves stored within the BL-3G.

2.6 Tab *Advanced 1*: Advanced modifications

This page allows for the BL-3G gyro to be accurately matched up to any RC transmitter / receiver system. Typically good quality RC systems will output accurate minimum and maximum pulses when the control sticks are moved to their minimum and maximum positions. Normally somewhere between 1 ms and 2ms respectively. They will also output a central pulse width when the control sticks are left in the central position. Normally 1.52ms. However these can vary and for not so good quality systems there will also be variances between different axes (pitch, roll, yaw and power). Hence it is wise to match up the RC transmitter with the gyro. It is also then possible to use a low cost transmitter system with the BL-3G gyro and still benefit from the full motion of the control sticks. The *'Default'* button sets the page to its factory default values.



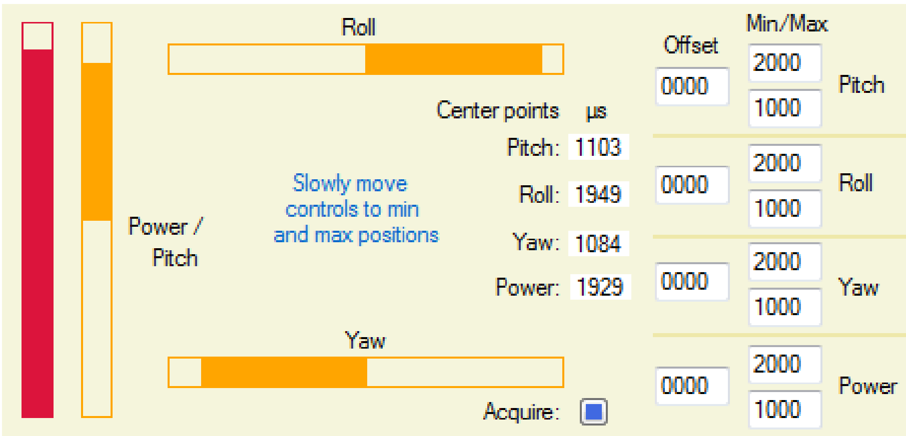
The procedure is to first match up the full range of the control sticks (*RC Tx input matching*), then to match up the central stick positions (*RC Tx fine trim centre points*). These procedures will be described below:

(Note that the other control inputs not matched are matched to the Power/Throttle input)

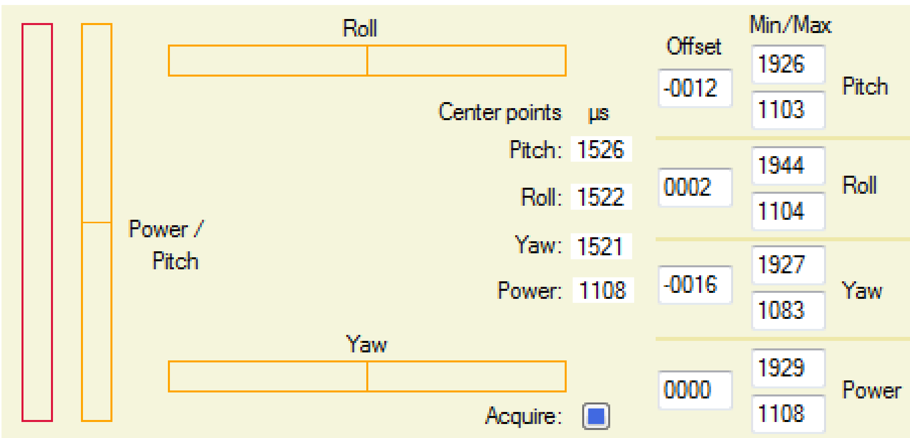
2.6.1 RC Tx input matching

The matching procedure is detailed here:

- **1:** Ensure the RC transmitter has its trim buttons centralized then switch it on
- **2:** Press the "*Start*" button within the *RC Tx input matching* section. (Note, the RC transmitter MUST first be switched on).
- **3:** Slowly move the control sticks to their minimum and maximum positions. The bars on the page will show the motion. You will also see *center point* pulse width numbers change. (Note that if power is not selected under the Advanced 2 tab page as an input then this will not be displayed).



- **4:** Leave the control sticks at their central positions (if power is also used then this should be left to its minimum position). The PWM values of these central positions can be seen as the *center point* values.
- **5:** Press the "*Match*" button. You will notice that the minimum and maximum positions (PWM pulse widths) will then be recorded in the *Min/Max* boxes to the right hand side of the stick motion bars. As will the numbers inside the *Offset* boxes.



The offset simply measures how far off centre the central pulse widths are from the middle of the min and max ranges ie offset = (min + max)/2 - actual center. This value is used internally by the gyro to set the central point for its outputs.

The values will be temporarily sent to the BL-3G gyro on completion of this procedure, but will be programmed into it only when the *send* button on the *basic page* tab is pressed.

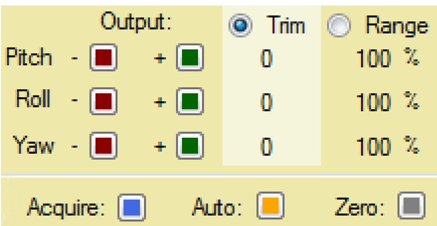
Note that the blue *Acquire* button can be pressed at any time to acquire the existing *Min/Max* and *Offset* values from the BL-3G gyro if required. Note also that the data within these boxes can also be modified manually if required.

This procedure means that any RC transmitter can be used with the gyro, ie the standard 1520µs, 960µs and 760µs pulses, but any other also. The values can also be entered into the boxes "by hand". More information is available by pressing the green information button. 

2.6.2 Control Surface Trim

It is advisable for the aircraft and also the gyro outputs to be matched up and in perfect trim. This section will detail how this is to be achieved.

Normally the aircraft is trimmed with the RC transmitter during flight. When a gyro is used this is also normally the way to do it, however it is not necessarily the best way. A signal input from the RC transmitter normally is a request signal requesting for a particular angular rotation rate. (Unless a gyro operates in an un-commanded mode, as detailed in section **2.9.6.2**). However, it is not such a good idea to have a rate request constantly in place as a trim. The reason is that such a request will be interpreted by the gyro controller as an error to be corrected, and as such will impact the heading lock feature causing high drift. It is also desirable to have no movement in the control surfaces when switching the gyro on and off in flight. The philosophy of the BL-3G gyro is to move the trim settings so as to be as close to the aircraft as possible, hence to move them to the gyro output.



Red buttons are provided to decrease trim or range, and green buttons to increase them. The radio button allows either the trim to be selected or the range. The range allows the end points to be set. Also available is a blue button to acquire the trim, and range that may have been previously set into the BL-3G for a particular aircraft.

The orange button is an auto trim feature for moving the trim from the RC transmitter to the gyro output. A grey zero button is also supplied to quickly set either trim or Range values to zero. Note that individual values can be set to zero by simply double clicking them.

Trim Adjust Procedure

- **1:** With the aircraft on the ground and connected up to the PC software the trim can be adjusted visually. This can be done either with the RC transmitter

or by adjusting the pitch roll and yaw settings on the *Advanced 1 tab* page, with the little square buttons provided. Note that although the trim will work in real time, the data will not be saved to the BL-3G gyro until the *Send button* on the *basic tab* page is activated in the normal way.

- **2:** The aircraft should then be flown in the normal way with the gyro switched off. (This can be achieved by assigning a real time input to the gyro on / off function, or by setting the gyro to off on the *Basic tab* page). The aircraft can then be trimmed in the normal way from the RC transmitter.

- **3:** Back on the ground the aircraft is connected up to the BL-3G PC tool again. On the *advanced 1 tab* page press the orange *Auto* button. This will automatically get the RC transmitter trim settings, and display them in the *Trim* section.

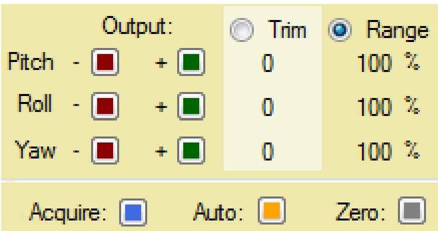
- **4:** If all other aspects of the BL-3G set up tool are as required go to the *Basic tab* page and press the *send* button. (Note that the aircraft trim will not be correct at this stage).

- **5:** Go to the *Tools tab* page, and press the *Test* button. You will see output data displayed graphically in green colour. Adjust your RC transmitter trim controls to remove the green indications. You will also notice the aircraft control surfaces coming back into good trim.

  The inputs to the BL-3G gyro are now set up to be exactly at their central positions and the trim settings have been successfully transferred to the BL-3G gyro outputs. Leaving the controls of your RC transmitter at their central positions the gyro can now be power cycled and no change to the aircraft trim should be seen. This confirms the trim is successfully set up. Note that the blue *Acquire* button is provided in case you exit the PC set up tool and later enter it again and wish to find out the trim settings inside the BL-3G Gyro.

2.6.3 Control Surface Range

The range section allows the end points to be set up when the Gyro is set to **off**. That means with full RC transmitter stick activated, the maximum control surface deflection is set up. Furthermore it is advisable that the range be set up such that when the gyro is switched on or off the control surfaces do not deflect to different positions.



With the radio button selecting the *Range* option, the red and green buttons allow modifications. Double clicking the range % number re-sets it back to 100%. The gray zero button resets all ranges to 100%. The acquire button will re-acquire any values previously sent to the BL-3G gyro. The *Auto* button has no effect in Range mode.

The procedure to set up the ranges uses a combination of the *input sensitivity* controls on the *Professional 1 tab* page and the *Range* settings on the *Advanced tab* page, as detailed here:

The PID gain box needs to be set to 11.000, and pots centralized before starting this procedure, and the range set up correctly with the Gyro off.

Range Adjust Procedure

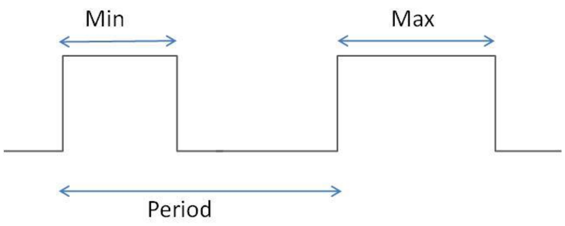
- **1:** With the aircraft stationary, on the ground, and connected up to the PC software tool the range is adjusted visually. First switch the gyro OFF (either with a real time input or via the gyro On/Off button on the *Basic tab page* - if with the *Basic tab* button, don't forget to then press the *Send* button) and ensure that when the RC transmitter levers are moved to their maximum positions the actual control surfaces also reach their maximum positions. If the maximum position for a particular control surface is not reached, increase the range by pressing the appropriate green button. If the maximum position is exceeded then reduce by pressing the appropriate red button. When complete press the *Send* button on the *Basic tab* page to send the new settings to the BL-3G memory.

- **2:** Switch the gyro ON (either with a real time input or via the gyro On/Off button on the *Basic tab page*). The *input sensitivity* controls on the *Professional 1 tab* page are now set up such that when an RC transmitter lever is at a maximum position, the corresponding control surface is also at its maximum end point. Note that after changing an *input sensitivity* value it is necessary to hit the *send* button at the bottom of the *Basic tab* page.

- **3:** If you have a real time input set to control the gyro on/off function, you can confirm that the range set up is correct by switching the gyro on and off while the RC transmitter levers are at their maximum positions. With perfect set up the control surfaces should not move appreciably when the gyro is switched on and off. Note that you can also go to the *Tools tab* page, press the *Test* button, and look at the PID data (the green coloured bars) and note that they should extend left and right and not change very much when the gyro is repeatedly switched on and off. This confirms the range adjust is successfully set up.

2.6.4 PWM detailed set up

If special requirements are needed the PWM minimum and maximum values are set up here. Also the PWM repetition time, ie the period (or frequency). For information the central pulse width and its frequency are shown.



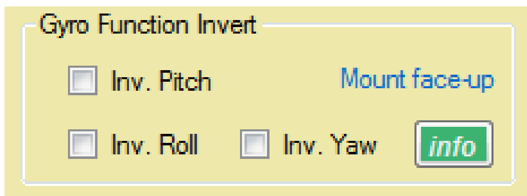
Note that if a PWM output type is set up in the *Basic tab* page output connection section (for example, by pressing the defaults button on that page), then any detailed PWM set ups made in the *Advanced tab* page will be overwritten. Similarly if the defaults button is pressed on the *Advanced 1 tab* page then the *Basic tab* page PWM output connection data will be overwritten. Note that any inconsistent values entered such as period too small compared to the maximum PWM pulse width then an error will be indicated. Note that the minimum PWM period that can be set is limited to 1.4ms. For standard servos the selection on the *Basic tab* page only needs to be made.

Note that for some older technology analogue servos it may be necessary to set a PWM period of higher than 15ms. If continuous or intermittent (every few minutes) vibration is heard / seen then it may be necessary to increase the PWM period.

Typical servo requirements can be seen by pressing the green *info* button.

2.6.5 Gyro Function Invert

This allows the application of the gyro correction signal to be reversed. Different aircraft will have different input signals and different servo connections and so it may be necessary to invert the gyro function for a particular axis.



2.7 Tab *Advanced 2*: Advanced modifications

This page allows for more detailed and not so common modifications to be made. It also allows up to 4 input channels to be programmed to various special functions as required.

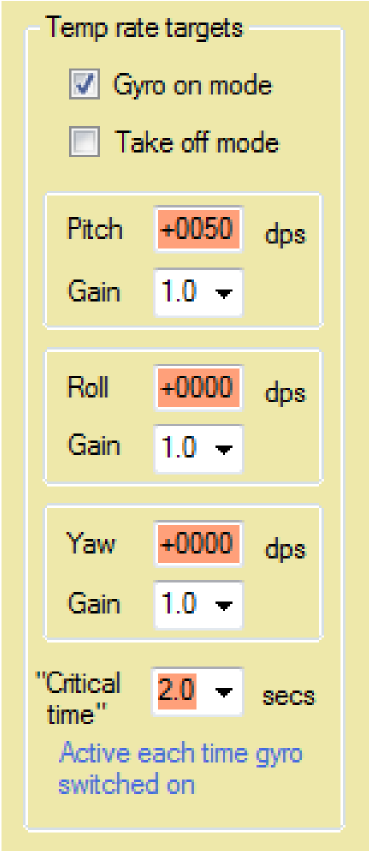
2.7.1 Temporary Gyro rate targets and gains - "Critical time" mode!

This section allows two modes to be enabled. The first mode detailed below is entered into every time the gryo is switched on with a programmable strobe. And the second once only during the take off run, when almost full power is first applied.

2.7.1.1 "Gyro on" rate and target changes

Normally the BL-3G will operate by giving appropriate control outputs to make the gyro rate zero for a particular axis. However this can be modified to any value within range. (I.e. within range of the data range selected on the *Professional 1* page). This then allows the gyro to lock onto a particular, and fixed angular rate rather than one of zero. The angular rate can be set up to be either positive or negative. This feature is useful when teaching novice flyers, and allows the aircraft to quickly recover from a spin situation. At the same time the gain applied can also be modified by a factor chosen from the *Gain* box. The way it works is as follows:

- During a spin it is necessary to stop the wings spinning, so a zero roll rate is selected
- If the spin direction is unknown also a zero yaw rate is selected
- A positive pitch is then applied to stop the aircraft loosing further height. (50 deg/sec in this example).
- The duration of all the above rates is then set up with the *"Critical time"* box. This sets the number of seconds the rates (and gains) are to last for. The actions (rate and gain changes) start when the gyro is switched on. An input is then set up to allow the gyro to be switched on and off. By default this is Input7, but can be set to any of the four input options. (See below).

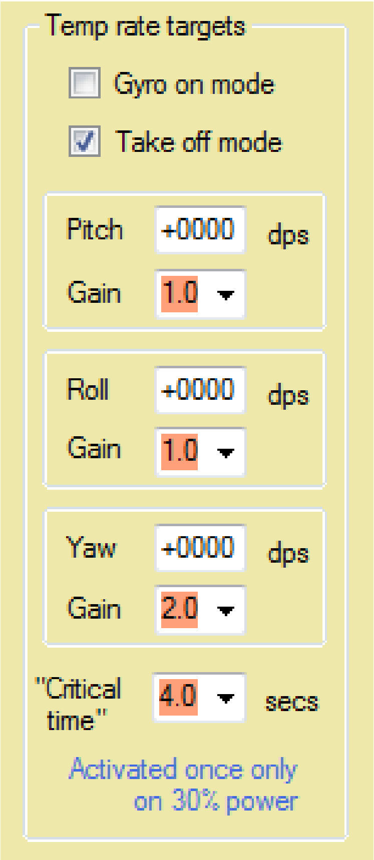


Note that a zero time selection in the *"Critical time"* box disables this function.

Note also that if a spin is entered into on purpose, then it can be decided beforehand which direction the spin will take (clockwise or anti-clockwise), in which case a spin opposite rudder rate can also be applied (by entering a value in the *Yaw* box). This will then be active at the same time as the positive pitch. To enhance the recovery (since the spin will normally be entered into at slow speed), an increased gain can also be applied with the *Gain* selection box.

2.7.1.2 "Take off" rate and target changes

This mode allows special rates and gains to be set during the take off run. It is entered into only when 30% of full power is applied. Hence the power input needs to be input to the BL-3G gyro (or alternatively any spare RC Transmitter channel suitably set up). In this mode the gyro is automatically switched on at the start with the normal pre-programmed settings (The pre-programmed gyro on/off switch will not operate prior to entering into this mode). Once 30% of full power is applied, it is assumed the aircraft is commencing its take off run. At this point the special gains (and rate modifications, if any) are applied. Typically this feature allows for straight and smooth take off runs even in high cross wind situations. To achieve this at slow speed the yaw gyro gain would typically be increased (doubled in the example shown here), while setting all the rate targets to zero. After the pre-defined "Critical time", of 4 seconds in our example, the "take off" mode is exited. This means the BL--3G will now operate as normal. And if a gyro on/off mode was programmed onto one of the real time inputs this will operate as normal.

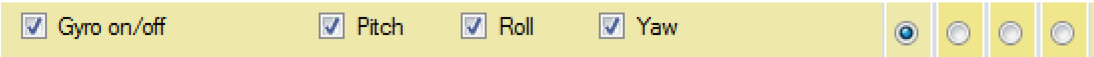


2.7.2 Programmable Real Time Inputs

Input7 is a dedicated real time input. Also, if so enabled (on the *basic tab* page), the input signals Input2, Input4 and Input6 can also act as real time inputs. The particular function is selected to be active on a particular input by checking the appropriate radio button on the right hand side. The various functions available are detailed here:

2.7.2.1 Gyro On / Off

It is possible to switch the gyro on and off in real time. If the input signal is below (less than) the central position the gyro is switched on, above it is switched off.

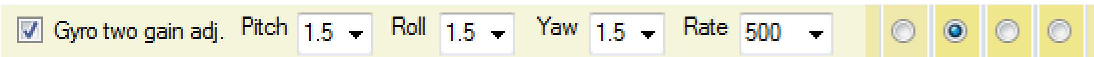


Furthermore, it is possible to allow for any combination of the axes (pitch, roll or yaw) to be enabled or disabled.

Note that if a system is used that does not have any available RC transmitter switches then the default is for the gyro to be enabled.

2.7.2.2 Gyro Two Gain Adjust

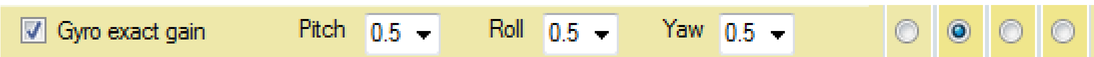
This function allows a gain multiplication factor to be applied in real time. This then allows for a high gyro gain during low speed or hover flying, and a much lower gain during high speed flying. It is also possible to set up an alternative gyro rate range. This may be desirable if fast flying is suddenly required or if bad weather and strong winds suddenly appear.



The picture above shows the default values of gain multiplication of 1.5, and a gyro rate range of ±500. The function takes effect when the programmed input signal is above (greater than) the central position.

2.7.2.3 Gyro Exact Gain

This function allows an exact gain to be applied, related to the value of the input pulse.



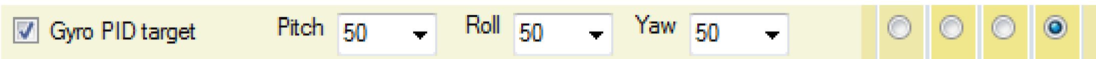
The above value is used to select one of the below table columns. For example if 0.5 is selected, then as the input signal goes from its minimum value to its maximum value the gain applied will be an exact gain running smoothly from 1.55 to 7.00. With the example of 0.5 set, and an input of say 50%, the gain applied will be 4.28.

Example set up values:	0.5	1.0	1.5	2.0
Input max (100%)	7.00	14.00	21.00	28.00
90%	6.46	12.91	19.37	25.82
80%	5.91	11.82	17.73	23.64
70%	5.37	10.73	16.10	21.46
60%	4.82	9.64	14.46	19.28
50%	4.28	8.55	12.83	17.10
40%	3.73	7.46	11.19	14.92
30%	3.19	6.37	9.56	12.74
20%	2.64	5.28	7.92	10.56
10%	2.10	4.19	6.29	8.38
Input min (0%)	1.55	3.10	4.65	6.20

Note1: On some RC transmitter the input range may be shown as ranging from -100% to +100%.
Note2: Gains are limited to maximum 35 and minimum 1 (inside the BL-3G Gyro).
Note3: Can check gain actual value by typing qExGainX; into tools page write window and pressing Tx USB button (qExGainX; for pitch, qExGainY;for roll and qExGainZ; for yaw).

2.7.2.4 Gyro PID Target

This function allows for definite pitch, roll and yaw rates to be set up in real time. This can be useful if, for example, a very accurate roll of exactly say 50 degrees per second is required, with perhaps a certain amount of positive pitch to keep the nose straight and level.



Rates are separately programmable for each axis.

2.7.2.5 Z axis mix to X and Y gain adjustment

This function adds a smooth gain factor (of 0.1 to 9) applied as the input goes from minimum to maximum value.

Z (yaw) subtracted from X (pitch) positive output (Output1)
Z (yaw) subtracted from X (pitch) negative output (Output2)
Z (yaw) added to Y (roll) positive output (Output3)
Z (yaw) added to Y (roll) negative output (Output4)

This function is used for multi-copter applications.

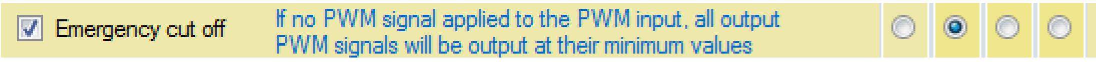
2.7.2.6 Power-in mode

The power (throttle) signal can be input onto a real time input and mixed into all the outputs with a programmable mix factor (0 to 100%) in multi-copter mode. This function is not available if the PID controllers are switched off.

This function is used for multi-copter applications. Also for the airplane "Take off" mode as detailed in section **2.7.1.2**.

2.7.2.7 Emergency cut off

All output signals will be set to their minimum values when the input is not within the top 75% of its range.



This then acts as a safety switch, should the controlling micro crash for any reason, or stop to output a signal, then all BL-3G gyro outputs will go to their default safe values. The safe value will be as set up under the *Basic tab* page, in the *Aircraft type* section. For applications where the gyro is driving motors this needs to be set to minimum value (So that power is switched off). In aircraft applications this needs to be set to mid value, such that all control surfaces are set to their mid positions.

2.7.2.8 I adjust or "Heading Lock" (Also known as AVCS mode)

The "I" referred to here is the Integrative part of the PID controller. This is the part that adds up all the error terms, i.e. all the accelerations measured by the gyro related to a particular axis that are not corrected for by aircraft movements. Hence the gain of this is used for the Heading Lock feature.

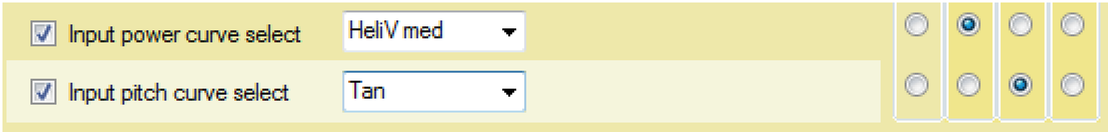
It is advisable to leave the *I gain* on the *Professional 1 tab* page set to zero. When enabled by a real time signal larger than the mid level the PID integrative gain is set up as an absolute number (i.e. not a multiplication gain factor). A typical value of 0.01 can be used for reasonable performance. Note that over time the gyro will lose the lock direction and so some drift will occur. This will be more pronounced if the input trim is not set up correctly.

This function is automatically exited when the RC Tx control stick (of a particular axis) is moved away from the central position.

This function is then enabled when the input is above the midpoint, and disabled when it is below.

2.7.2.9 Input power and pitch curves

It is sometimes useful, to be able to switch between one input curve and another.



This is possible by setting up the *input power curve select* or *input pitch curve select* options. If, as shown above the *HeliV med* curve is selected (when Input2 input is activated in the example above), as the power curve option, this curve will be switched to when the input on the select input goes above the 50% position. If the programmable input is less than the 50% level then the normal curve as selected from the *Curves* page tab is used, if above the input curve will immediately be switched to the *HeliV med* curve.

Similarly the pitch curve can also be switched in real time. (To a tangent curve in the example above, using Input4).

The available options for the power curves are:

Linear
Square
Inv square
Cube
Inv cube
Sigma low
Sigma med
Sigma high
HeliV low
HeliV med
HeliV high
Flat low
Flat med
Flat high
Tan
User1
User2

The available options for the pitch curves are:

Linear
Square
HeliPitch low
HeliPitch med
HeliPitch high
Flat low
Flat med
Flat high
Tan
User3
User4

2.7.2.10 Flaps Control Input

Assignment of an input channel for the flaps control signal

2.8 Tab *Professional 1*: Professional 1 modifications

This page sets up specific gyro control parameters as detailed here. The *'Default'* button sets the page to its factory default values.

2.8.1 Pitch, Roll and Yaw axes PID controllers

The pitch, roll and yaw axes PID controller parameters can be set up individually. *P gain* is the proportional gain, *I gain* is the integrative gain and *D gain* is the differential gain. *Integral windup* is the tendency for the integral part to keep adding up (especially during static conditions) and could go on to a very high value indeed if not kept in check. The integrative part of the PID controller is actually used as a *heading lock* for aiplane applications. (See section **2.7.2.8**) It is not advisable to modify this setting on this page, but instead it can be modified via a real time input (see the *advanced tab* section). By using a real time input the *I gain* for the heading lock can be enabled and disabled during flight, thus avoiding the integral windup problem during static conditions. The overall effect of the gyros is modified with the *PID gain* box. This then is the most important parameter to modify for individual aircraft types and performance requirements. Hence it is highlighted in yellow, and also has buttons to the right for quick up and down modifications. The overall limits to the gain values are between 1 and 35.

The small potentiometers are shown here too. These are modified with a small screwdriver on the gyro PCB itself. Hence the final gain is a combination of the gain set up in the *PID gain* box as detailed above. In fact the potentiometers adjust the gain set up in the *PID gain* box by a certain positive or negative percentage. The potentiometer setting is indicated in the *Manual gain adjust* text. The final gain is show in the yellow *Total gain* box. The purpose of the PCB potentiometers is to allow

the gain to be easily and quickly modified in the field without the need to connect to a PC each time.
The input signal to the PID controllers can also be set up here. This is the sensitivity of the input control of the RC transmitter (when Gyro is ON). For example, if a small pitch is requested by moving the pitch lever on the RC transmitter up, this will send a command to the pitch PID controller to request a particular rate, for example a 10 degrees per second rotation. Whether this is a small movement of the transmitter lever or a larger one is set up using this *input sensitivity* box. (Please also see section **2.6.3.2** on control surface range set up).

The PID controllers can also be disabled, in which case only raw gyro rate data is output. This feature is for advanced users wishing to use the gyro purely as a sensor with no control output.

2.8.2 Automatic Gain Control (AGC)

This feature limits the gain if unwanted feedback oscillations start to set in. These oscillations are similar to flutter and are caused when high gain levels are used. This is similar to using a microphone too close to the speaker output. The speaker output will feedback into the microphone, which will again further amplify the signal. This positive feedback can also happen with aircraft control surfaces.

2.8.3 Rate data range

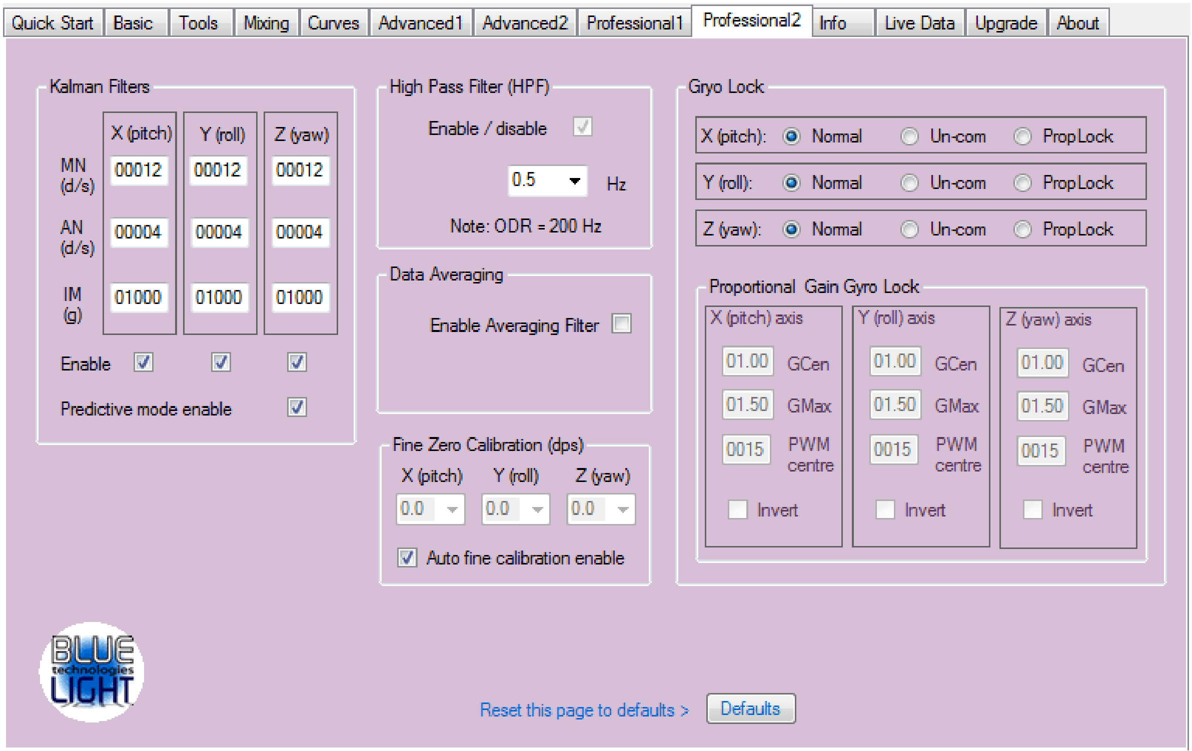
The range over which the gyros operate is defined here, with values in degrees per second (dps). Note that the high pass filter cut off frequency options (on the *professional 2 tab* page) are modified depending on the data range chosen. If a not so large aircraft is flown in very turbulent weather conditions at high speed then rather large accelerations may be experienced by the craft. In such conditions it may be advisable to set a range of either ±500 or even ±2000 dps. (It is also possible to modify these with a real time input as can be seen on the *advanced tab* page).

2.8.4 Gyro data rate

The Gyro data rate is specified here. This is the rate at which gyro data is taken out of the ST gyro device onboard the PCB. For each rate there is a corresponding cut off frequency that has also to be specified.

2.9 Tab *Professional 2*: Professional 2 modifications

This page sets up more specific gyro control parameters as detailed here. At the bottom of the page there is one button:
'Default' button: This sets the page to its factory default values.



2.9.1 Kalman filters

The Kalman filter parameters are set up here. This filter is used to eke out the real data from the typical inherent noise associated with any signal acquisition hardware. The reader is encouraged to study the Kalman filter in dedicated texts. The Kalman filter includes a model of the physics associated with the aircraft and its motion (rotation about each axis) caused by the control surfaces. This is known as the *state model*. The state model then aids the filter in accurately being able to find the most accurate value for the actual rotational rate of each axis.

2.9.1.1 IM (Inertial Mass)

It is unreasonable to expect any commercially available RC gyro to excel for every aircraft type, size and user requirements. Hence an *IM* (Inertial Mass) input is given here to get some estimation of the size of the aircraft. This number should be set to the aircraft weight for normal flying. This number can be set higher if the aircraft is generally flying slowly, or lower if it is intended to fly at high speeds.

2.9.1.2 MN (Measurement Noise)

Different aircraft will also have different vibration or noise characteristics. This is another input to the Kalman filter. The actual live gyro data can be seen from the *live data* tab page, and so the setting here can be considered to be x10 the typical noise

variation seen. A typical value for electric flyers is around 12 dps. Generally the value used will be increased, for example, for noisy petrol engine aircraft or reduced for gliders or electric flyers.

2.9.1.3 AN (Acceleration Noise)

The acceleration noise is the vibration of the aircraft for all sorts of external factors such as, aerodynamic design, control surface flutter, loose hinges on control surfaces, bad weather etc. Acceleration noise is the actual accelerations experienced by the aircraft rather than the noise in the inaccurate measurement of these accelerations by the gyro (which is the measurement noise mentioned above). Typically this can be set to a reasonably low level of 4 dps, but can also be increased for poorly designed aircraft.

Note that the Kalman filter can be switched off for each axis and only data averaging can be used instead if required.

2.9.2 Predictive mode

The Kalman filter contains a physical model of the aircraft and its motion (the *state model*). This model is a generic model since clearly not all parameters of an individual aircraft are available to it. This physical model to some extent models the aircraft dynamics. Hence one aspect of the Kalman filter is that for applications where large dynamic changes are occurring, such as for aircraft performing aerobatics or any large control surface movements the predictive mode will help the Kalman filter to calculate more accurate actual gyro rates from the raw sensor inputs. For aircraft such as hovering multi-copters it is better to disable this feature. This feature should also be disabled if an offset is used (such as an input PRY curve where the central stick position gives a non zero output). Note that even if enabled the feature will automatically be disabled inside the gyro during *heading lock* mode. (See *advanced 2* tab).

2.9.3 High Pass Filter (HPF)

The HPF is always enabled, but the cut off frequency can be adjusted. The available cut off frequency options depend on the data rate chosen in the *Professional 1* page. The options are shown here:

ODR (Hz)	***Cut off frequency (Hz)***									
100	8	4	2	1	0.5	**0.2**	0.1	0.05	0.02	0.01
200	15	8	4	2	1	**0.5**	0.2	0.1	0.05	0.02
400	30	15	8	4	2	**1**	0.5	0.2	0.1	0.05
800	56	30	15	8	4	**2**	1	0.5	0.2	0.1

ODR is output data rate.
When enabled, defaults are shown in bold text.

Particular low frequency noise can therefore be removed from the gyro measurement should this be a problem with particular aircraft.

2.9.4 Data averaging (default off)

An additional optional filter is provided here to simply take a rolling average of the data after LPF, but before the Kalman filtering. If enabled, the number of samples that the rolling average is to take effect on must be entered. (Maximum allowed is 99). Note that this simple filtering will smooth out any noise in the gyro measurements but will do this at the cost of a slow response time (known as phase lag). This filter can be applied at the same time as the Kalman filtering if required. If enabled it is recommended that numbers not much larger than single digit numbers are used.

2.9.5 Fine Zero Calibration (default auto)

Each axis can have a small offset added to each data point to ensure very accurate zero rate measurement when static. This can be set up with reference to the live data display on the *live data* tab. This can be done once and when programmed into the BL-3G will always be used (This is recommended since the Gyro is ultra stable in time and temperature). Alternatively, and by default, when the BL-3G is powered up it will take multiple readings over a period of some 7 seconds and calculate its own offset for optimal zero level set up. If this option is used it is important that during these first 7 or so seconds no movement of the aircraft is made. As soon as the blue LED blinks again it is ok to move the aircraft. Note that if any movements / rotations above 18 degrees per second are experienced, the BL-3G will ignore the auto calibration and revert to previously stored auto calibration results.

2.9.6 Gyro Lock

The gyro lock has three options, each separately programmable for each axis.

2.9.6.1 Normal mode

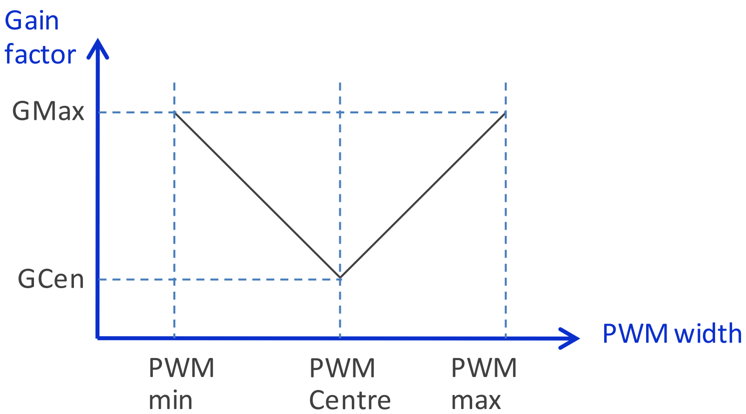
In Normal mode the outputs are simply modified with the gyro data. I.e. Output1 has the pitch gyro data subtracted, Output2 has the pitch gyro data added and so on. No PID gain changes are made. The input from the RC receiver is taken to be a rate command. In other words a particular position of the RC transmitter lever will send a pulse of a certain width to the RC receiver, which the BL-3G gyro will interpret as a request for a specific rate of turn to be applied to the particular aircraft axis.

2.9.6.2 Un-commanded mode

In this mode only if an input signal does not vary from a previous one will the PID output with gyro data be applied, otherwise no gyro data will be used. It is assumed a variance is indication that a control surface movement is required / commanded. If no variance it is assumed stability is required and hence the gyro will operate as normal. In this mode a change of the RC transmitter lever will act in exactly the same way as it would, should no gyro be present. In other words the RC transmitter lever will move the particular aircraft control surface to a specific angle.

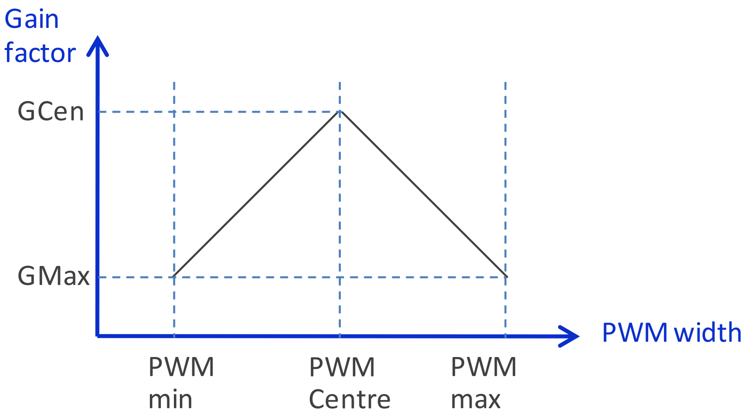
2.9.6.3 Proportional mode

In this mode the rate of change of the gyro lock gain factor needs to be set up. I.e. the gain at the central PWM pulse width (*GCen*) is set. For example a gain factor of 1 will mean there is no change in the gyro final gain at the central PWM position (i.e. *PWM centre* typically at 1.5ms), but at the extreme positions (i.e. typically at 1ms and 2ms) the gain is multiplied by a factor (*GMax*), which by default is set to 1.5. If the *Invert* option is selected the gain at the central PWM pulse position (PWM centre) is set to the maximum (*GMax*) and falls off (linearly) either side until at the extremes it becomes the minimum value (*GCen*).



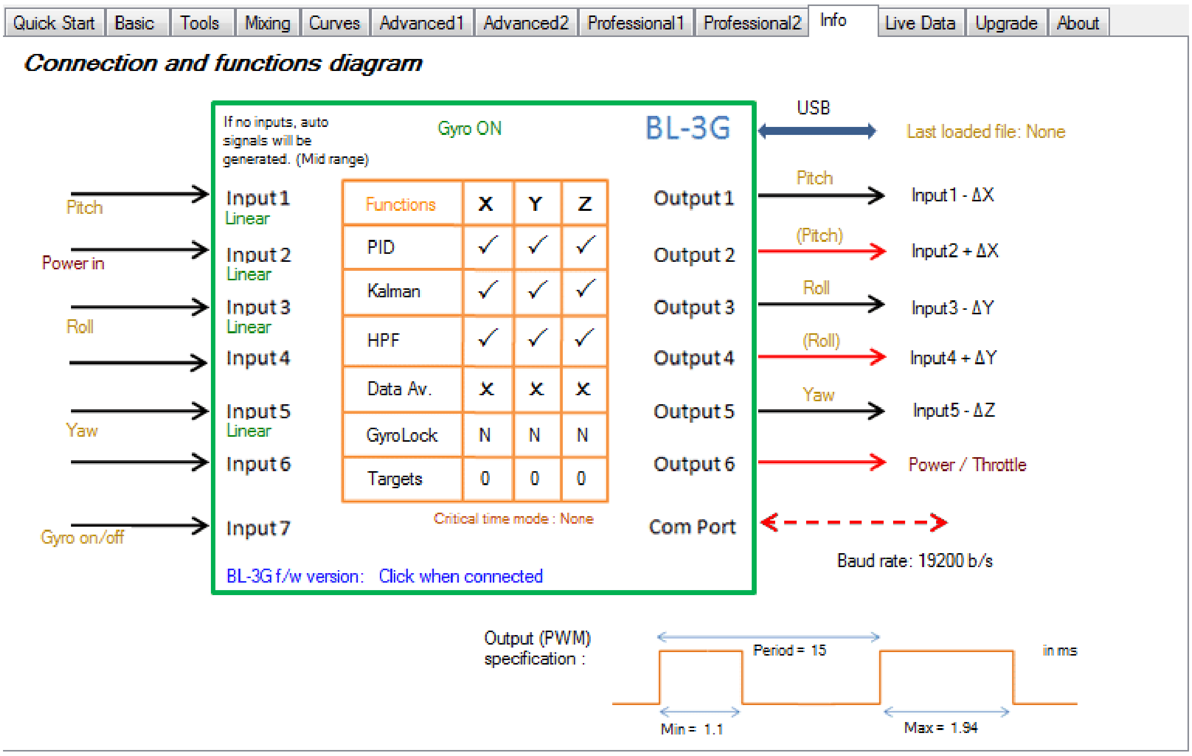
For the rudder, as an example, the PWM min position is at the full left rudder position and PWM max is at the full right rudder position.

If the *Invert* box is checked then the gain factor applied is as shown here:



2.10 Tab *Info*: Set up information display

This page shows the set up parameters in a graphical format and is updated in real time as set up changes are made.



The functions and how they are enabled is shown in the centre with the inputs to the left and the outputs to the right. The PWM pulse train is also shown as set up. The above is the default view. The software version inside the BL-3G is displayed at the bottom left automatically after successful communications has been set up (see next section).

The purpose of this page is simply to make sure the gyro has been set up as required. Note that X is pitch, Y is roll and Z is yaw. The page, as shown above, is informing the connection to the aircraft is as follows:

- The USB is connected. The UART port is also available, but not connected.
- Output1: Connect to the pitch servo of the aircraft. (If your servo is in another orientation then the inverse signal is available on Output2).
- Output3: Connect to the roll servo of the aircraft. (If your servo is in another orientation then the inverse signal is available on Output3). If two servos are used then Output3 and Output4 can both be used. (If it is required that they both have the same signal then Output4 can be inverted from the *Basic tab* page).
- Input2 is set up as a real time input with the *throttle in* function mapped to it.
- The throttle output has been mapped to Output6.
- Input7 is set up as a real time input with the *Gyro on/off* function mapped to it.
- The gyro is ON and has Kalman and high pass filtering enabled, but data averaging disabled.
- The input curves are all set to linear.
- The gyro lock is set to normal mode.

- Rate targets are all set to 0, meaning the *critical time* mode is disabled. (*NZ* will appear, meaning *Non Zero,* if target rates are set up in the *Rate targets* section of the *Advanced 2 tab* page).
- The BL-3G gyro will output signals with minimum 1.1ms and maximum 1.94 ms pulse widths, with a frequency of 15ms.
- The software version number is available when the "Click when connected" text is clicked.
- If no input signals are supplied the inputs will default to the mid range value.

Note: Input1 - ΔX simply shows that the gyro correction to pitch will take place in the opposite direction to the pitch motion caused by some external disturbance.

IMPORTANT NOTICE:

The information tab page is a good indication how the system should be connected according to the settings selected in the BL-3G set up tool, however:

THE PERFORMANCE OF THE AIRCRAFT SHOULD BE TESTED ON THE GROUND PRIOR TO ANY FLIGHT.

Checks should also be made that the gyro function is the correct way round for any disturbances and that any flap functions operate the correct way round too.

2.11 Tab *Live data:* Data analysis

When both developing and flying aircraft such as fixed wing, multi-copters and other UAVs, the amount of induced noise into the data involved with the system stability is of paramount importance. It is for this reason that a page is dedicated to looking at the actual data when the system is in full operation.

Options are given to view the raw gyro rate data (*Raw*), or the post processed, i.e. the data after the filtering blocks (*Post*). *Raw* data is displayed in black colour, and *post* data in blue. The data is viewable as though an oscilloscope were connected internally. In this way the system parameters such as LPF, data averaging and Kalman filtering can be adjusted and the results actually seen. A standard deviation function (actually, square root of the bias-corrected variance) is also calculated for the particular data set acquired.

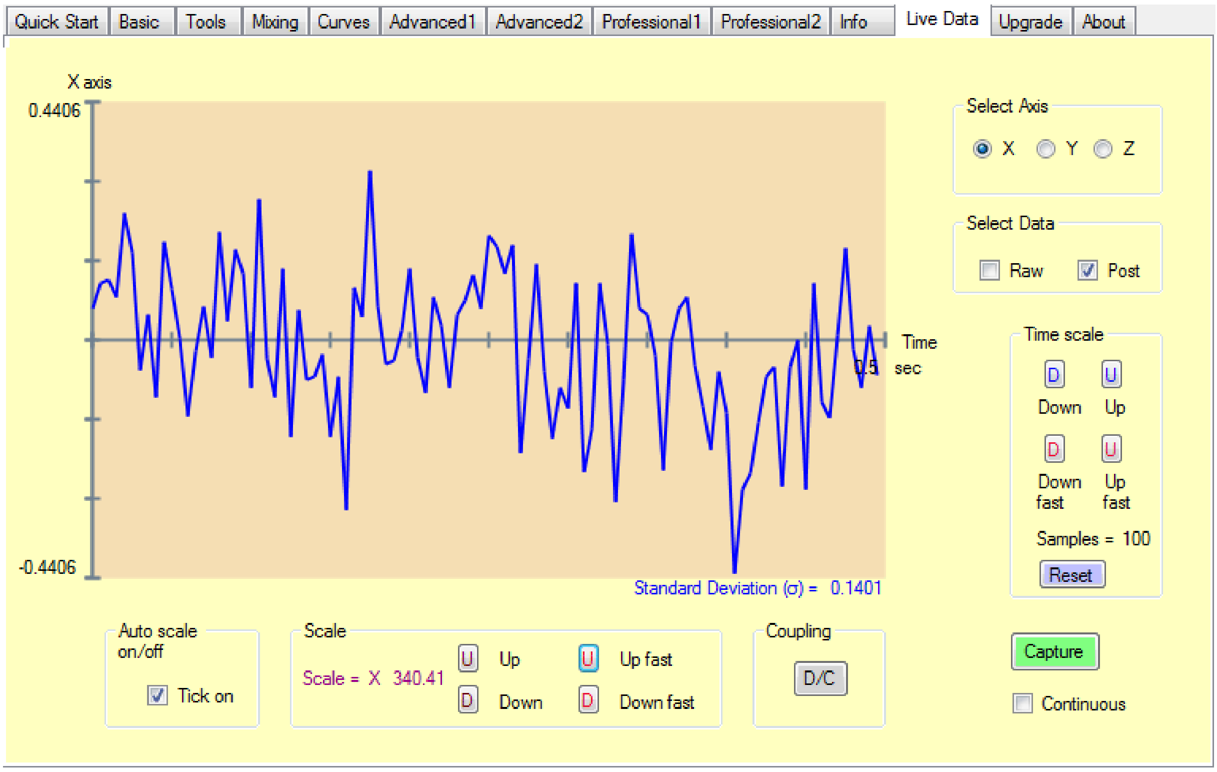
$$S = \sqrt{\frac{\sum^{N}(x-\bar{x})^2}{N-1}}$$

Where x bar is the data set average, and N is the number of samples in the data set.

Internally a 5ms loop is run prior to using the data to generate the outputs. Hence with the default 100 samples, the time axis is split into 5ms segments. By default 100 data points are acquired (0.5s total time period). This can be changed with the time axis *up* and *down* buttons, and reset back to 100 with the *reset* button.

Regarding the vertical axis, options are given to automatically scale the data to fit onto the screen. (This is the default set up). Otherwise user own scaling can also be performed with the *up* and *down* buttons provided.
With the aircraft static and engine/motor switched off the noise level should be within about ±1 degree per second. The static level can be adjusted with the controls on the *Professional 2 tab* page. This is detailed in section **2.9.5** on *Fine Zero Calibration*. The signal can also be used to assess the most appropriate parameters to use when setting up the Kalman filters, as discussed in section **2.9.1**.
Note that an A/C D/C coupling button is also provided. This is useful to centre the waveform in the case of a post analysis where a DC level is present from a trim offset, or a power signal (in the case of a multi rotor application) or if the Kalman predictive mode is enabled (This will result in a small DC offset in static conditions). Also in the case of very small raw gyro data offsets (in *Raw* data view, i.e. prior to calibration).

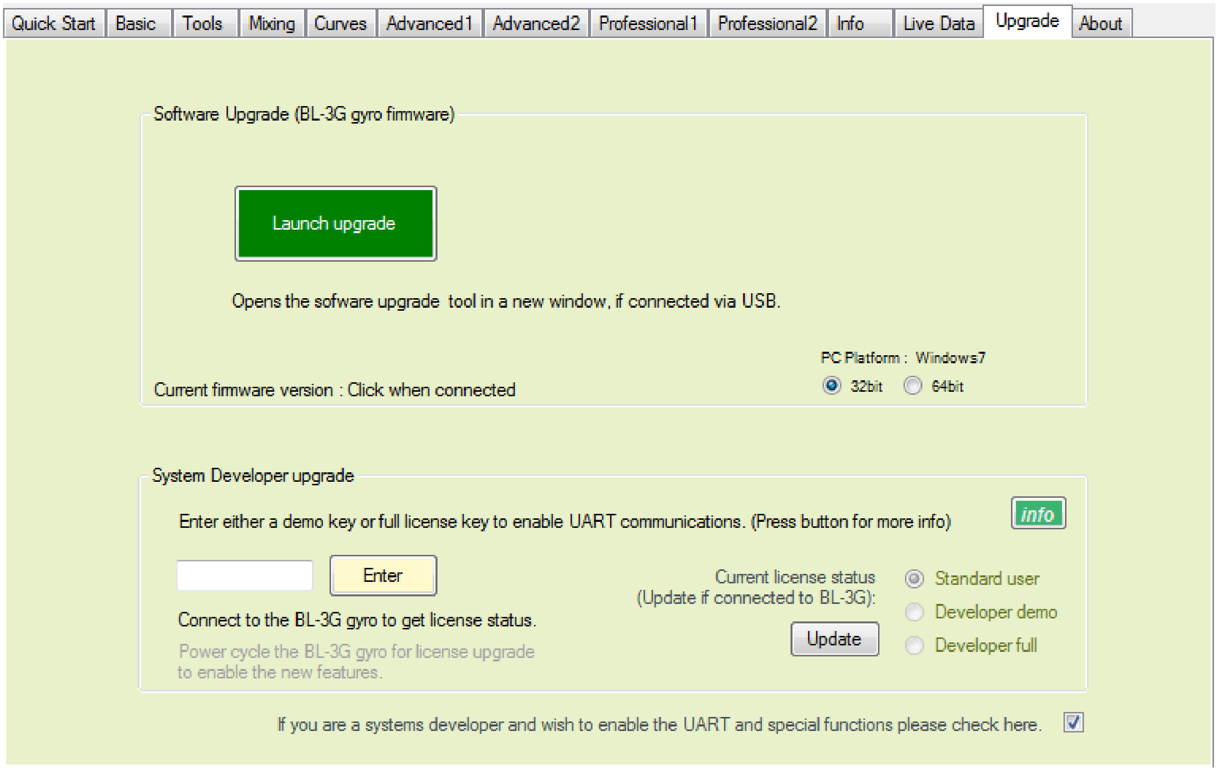
A typical static gyro trace is shown below to get a better idea of the noise floor:



If the gyro is correctly calibrated (i.e. not moved during power up if set to *auto fine calibration* mode), the waveform will stay within around ± 0.5 degrees / sec.

2.12 Tab *Upgrade:* Upgrade firmware

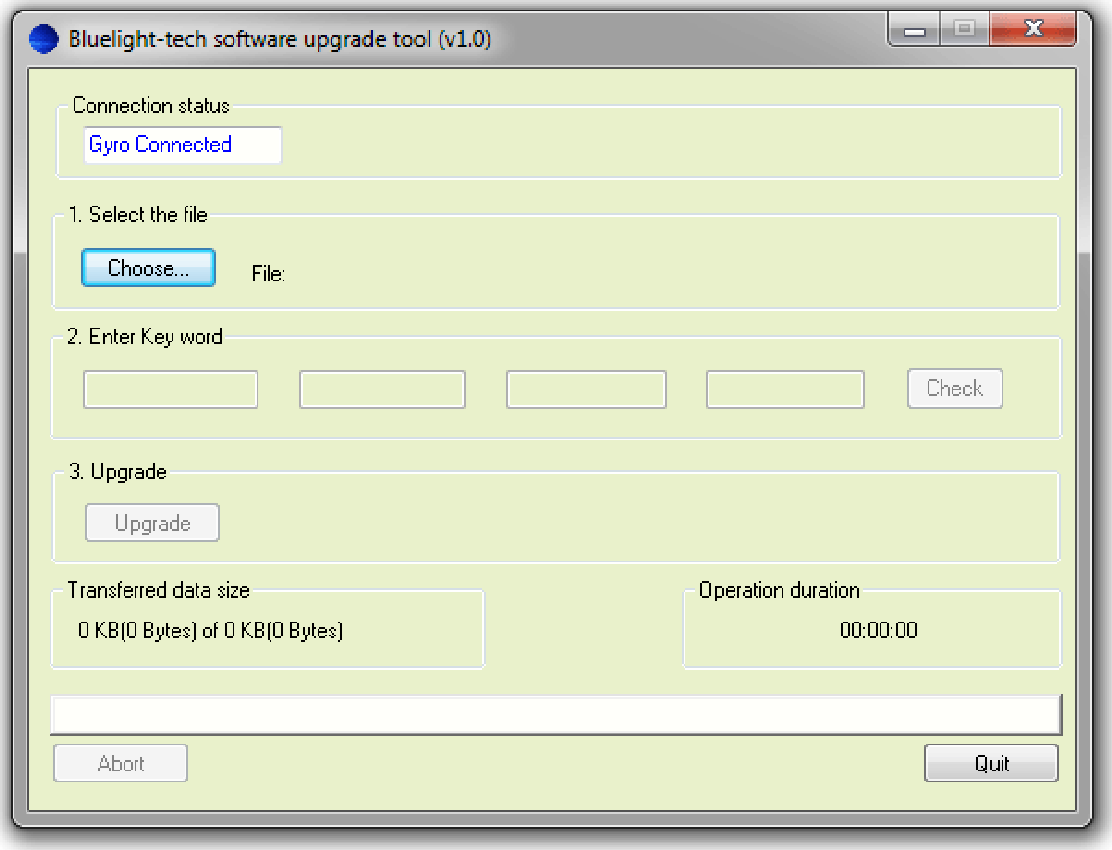
There are two upgrade paths. The first box entitled *Software Upgrade (BL-3G gyro firmware)*, allows for the actual firmware of the gyro to be upgraded. Updated files will be available for download from Bluelight website, if and as they become available. The second box entitled *System software upgrade* enables the UART communications port on the BL-3G gyro as well as the special commands to allow programming and data extraction from the BL-3G gyro. This is for systems developers wishing to install the BL-3G onto their own PCBs or otherwise onto their own developed systems.



2.12.1 BL-3G firmware upgrade

The following procedure can then be used to upgrade the gyro unit:

- Connect the gyro to the PC via the mini USB connector
- Hit the *Launch upgrade* button. A new window will pop up, as shown here:



- Making sure the *Gyro connected* indication is visible in the first little box, three easy steps follow.
- Step 1: Choose the file (*.efu) to download which should have been saved to your PC hard drive or connected memory device.
- Step 2: Enter the 40 digit key word given to you by Bluelight Technologies. If you don't have this simply send a mail to sales@bluelight-tech.com requesting one. Press the *Check* button when done
- Step 3: Press the *Upgrade* button. Progress will be displayed in the windows below. The upgrade will progress in two phases. Phase one is the erasing of the previous firmware, and phase two the programming of the new firmware. The complete re-programming time should be less than 20 seconds.
- When complete go ahead and press the *Quit* button. You must now unplug your Gyro from the PC and also from any external power source to power cycle it.

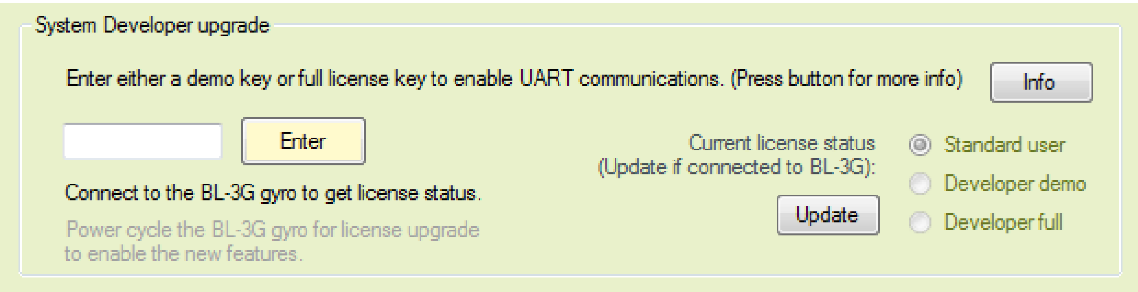
2.12.2 BL-3G system developer upgrade

In order to start to use the UART and special commands a license must be acquired. Two licenses are available:

1) A free demo license (*Developer demo*) which allows all features to be used for a fixed duration of 5 minutes. After this time a BL-3G gyro power cycle will be necessary, then the features may again be used. In this way the developer can check out the features. Note that the BL-3G PC set up program can be configured to run all its set up entirely by using the UART port rather than USB. In this way a developer can test and see the UART working correctly.

2) A full demo license. Once programmed into the BL-3G gyro the gyro will operate with full UART and special commands mode all the time. A small charge will be made for this license.

The procedure for installing a license is described here:



- Acquire the appropriate license from Bluelight technologies. Either send an e-mail to sales@bluelight-tech.com or see our website for more details (www.bluelight-tech.com/Buying.htm)
- Simply copy and paste, or type in the license number into the box on the left hand side.
- A message will pop up inside the box to indicate the type of license and if valid. If valid and a USB connection to the BL-3G exists (not UART only connection) then the license will be programmed into the BL-3G.
- Press the *Update* button to the right to ensure the correct license is indeed inside the BL-3G gyro.
- For the features to take effect inside the BL-3G a power cycle of the gyro will be necessary.

The additional features available are detailed in section **4.0** of this document

2.13 Tab *About:* Bluelight Technologies

The last tab simply gives contact information about Bluelight Technologies (the designers of the BL-3G gyro) and where to find more information and software updates / downloads.

3.0 Detailed Specifications

3.1 Functional specification

Feature	Functional specification
Quick Start	
Standard Aircraft	A list of standards aircraft to choose from
Gyro function	Ability to change the Gyro function direction for each axis
Drag 'd drop box	Drag and drop box for aircraft parameter .txt files
Send to Gyro	Button to send all parameters to the BL-3G Gyro
Mounting	Up-side-down mounting option
Basic	
Stability	Pitch, roll, yaw axes with programmable gains
Gyro Gain adjust	Via PC software or rotary switches on the PCB
Inputs	Pitch, roll, yaw, and optional x4 inputs (power and/or RC Tx switches). Ability to invert the input signal
Outputs	Pitch, roll, yaw control and also power (optional)
Output Mixing	For "Flying wing" (no rudder), "multi copter", dual servo applications
Output options	Addition of bias (sub trim), invert signals
Servos	Can connect to Digital, analogue, speed controller, or Narrow pulse.
Send to Gyro	Button to send all parameters to the BL-3G Gyro
Tools	
Save to file	All unit set up data can be saved to PC HDD or connected memory. Any number of set ups can be saved. Typically one per aircraft type.
Read from file	Any pre-saved files can be loaded from PC to the BL-3G set up program.
Connection check	The PC tool checks to make sure communication with the gyro unit is possible
Command mode	Commands can be sent to the unit and responses received
Quick check	Graphical bars on the PC set up tool are provided to show the gyro can measure ok and can also generate outputs to the control surfaces to counter the measured rotations.
Temperature	Temperature sensor read out and calibration
Mixing	
Aircraft types	Mixing for flying wing (delta wing), V-tail, and multi-copter. Tight turns feature (mixing some roll into the yaw)
Flaps	Normal flaps, airbrake function, flaperon function, and flap pass through. All with function application reverse option. (Two stage flaps supported)
Curves	
Types	X4 user defined curves (11 points) to adjust power, pitch, roll and yaw inputs. 17 pre-defined curves (smooth curves, ie infinite points)
Advanced 1	
Fine matching	Matches with any RC transmitter (Tx) for optimal performance
Trim adjust	Adjust pitch, roll and yaw trim
Range adjust	Adjust pitch, roll and yaw movement end points
Servo advanced	Programmable output signal to support any servo or controller.
Gyro function	Ability to invert the gyro function on a per axis basis
Advanced 2	
Crash avoidance	Set 'rate' targets for pitch up and zero roll for programmable time/gain
Straight take-off	Set 'gain' target for zero heading drift for programmable time and gain
Heading lock	Set with RC Tx switch off, for programmable time
Gyro on/off	Set RC Tx switch to switch gyro on and off
Gyro two gain	Set RC Tx switch to flip between low and high gain for slow and fast flying.

Gyro exact gain	Set RC Tx signal to give an exact gain setting
Constant Roll	Set 'Gyro PID target' to desired roll rotational rate, with (optional) pitch rate set to zero to give nice clean and regular aircraft barrel roll performance
Constant Pitch	Set 'Gyro PID target' to desired pitch rotational rate, with (optional) roll rate set to zero to give nice clean and regular aircraft loop performance
Multi-copter mix	Gain adjust for the mixing of yaw into all multi rotor motor outputs
Power in mode	Allows the power signal to be mixed into all output signals. Used for QR since outputs are all connected to motor controllers
Emergency cut-off	All control surfaces go to their safe positions if a programmable input signal stops transmitting. Safe is central positions for airplane applications or minimum positions for Multi-rotor applications
Rotational lock (Pitch, roll, yaw)	Heading lock, roll lock or pitch lock activated (with programmable gains) when an RC Tx switch is toggled
Curve selects	An RC Tx switch can be programmed to switch between curves for either power or pitch axes.
Flap selection	Flap input channel selection
Professional 1	
Internal gyro set-up	Detailed set-up of the PID controllers for the pitch, roll and yaw gyro functions.
Strong wind mode	Allows modifications of how the gyro measures the aircraft rotations about pitch roll and yaw axes, ie its sensitivity. Can set to ± 2000 deg/sec range in case of very turbulent and bad weather flying.
Mix function only	Disable the gyro functions for gyro to act as mixer / curve unit only
AGC	Automatic Gain Control to limit flutter type oscillations
Professional 2	
Aircraft type and environment matching	Can adjust the internal Kalman filters to match the environmental noise and vibration of the aircraft. Also available is an averaging filter for very high noise environments where gyro high speed operation is not so critical.
	The Kalman filtering can also be adjusted to match the aircraft model size for very fine tuning (Inertial mass parameter).
Gyro zero calibration	The gyro zero calibration can be set to manually or automatically each time the unit is switched on. Manual set up is achieved graphically.
Gyro lock modes	The 'gyro lock' feature can be set to 'normal' of 'un-commanded'. User preference for how the aircraft operates when the gyro is switched off. (See user manual for details). It can also be set to proportional mode, see below.
Control surface flutter support	When control surfaces extend to their maximum reaches, turbulence and or flutter may set in, in which case it may be necessary to have an automatically higher gyro gain proportional to the control surface location. (Alternatively this can be set to operate inversely proportional).
Information	
Graphical display	A display is provided to give graphical feedback as to the unit set up
Live data	
Oscilloscope mode	The PC tool acts as an oscilloscope, with standard deviation read-out, to show the gyro measured data, pre and post filtering. This to characterize the aircraft noise environment.
Upgrade	
BL-3G firmware	The BL-3G firmware can be upgraded as updates become available.
Developer upgrade	To allow for the PCB module to be installed into a developers own system a UART connection might be useful for programming and operation of the final system. Also many new commands are made available. To enable these features it is necessary to purchase an upgrade license. A free demo license is also available.

3.2 Hardware specification

Parameter	*Test condition**	*Min*	*Typical***	*Max*	*Units*
X, Y and Z gyro					
Full scale (FS) rate range	User programmable		± 250		dps (degrees per second)
			± 500		
			± 2000		
Sensitivity	FS = ±250 dps		8.75		mdps/digit
	FS = ±500 dps		17.50		
	FS = ±2000 dps		70		
Sensitivity change vs temperature	-40 to +85 ^{0}C		± 2		%
Rate noise density	At 50 Hz BW		0.03		dps/sqrt(Hz)
Digital zero rate level	FS = ±250 dps		± 10		dps
	FS = ±500 dps		±15		
	FS = ±2000 dps		± 75		
Zero rate level change vs. temperature	FS = ±250 dps		± 0.03		dps/^{0}C
	FS = ±2000 dps		± 0.04		
Absolute maximum acceleration	For 0.1 ms			10,000	g
PWM					
Input channels			x7		
Output channels			x6		
PWM accuracy	All outputs	-	-	1	µs
PWM input pulse high		2	1,520	20,000	µs
PWM input period		1000	10,000	20,001	µs
PWM output pulse high		100	1,500	65,000	µs
PWM output period		101	10,000	65,001	µs
Communications					
USB (mini) interface***	Full speed		64		Bytes/ms
USB power sourcing				100	mA
UART channels			x1		
UART speed		19,200		19,200	b/s
Interface voltages					
PWM input voltage	All inputs	2.2		7.3	V
PWM output voltage	All outputs			3.3	V
PWM output current	Drive current		5		mA
Temperature					
Temperature sensor output change vs. temperature			-1		^{0}C/digit
Temperature sensor refresh rate			1		Hz
Operational temperature range		-30		+85	^{0}C
Power					
Input voltage (Vdd)		3.3	5	20	V
Operational current consumption	At 5v input supply voltage		45		mA
Power routing (To driver servos/ESC)	Any PWM input to any PMW outputs	0	2.5	3.0	A

*Test conditions at 25^{0}C   **Typical specifications are not guaranteed   ***IEC 61000-4-2 level 4 compliant

4.0 System developer additional features

From the Tools page

Data request commands, or programming commands can be sent to the BL-3G. These are the standard commands. It is also possible to send commands directly to the ST L3GD20 device. These two options are detailed hereunder.

4.1 Standard commands

When a read only *data request* command is sent to the BL-3G the format is as shown here

n char command	;

n is any number of characters (Char or byte). End of command is with a "**;**"

When a *programming* data command is sent to the BL-3G the format is as shown here

n char command	=	***i*** char integer	.	***f*** char fraction	;

n is any number of characters (Char or byte). ***i*** is any number of characters (Char or byte) not greater than 10 representing the integer part of a number, and ***f*** is any number of characters (Char or byte) not greater than 10 representing the fractional part of a number. The integer part can be prefixed with "**-**" for negative numbers. It is also acceptable to have a "**+**" for positive numbers but this will be ignored by the BL-3G. All programming commands (i.e non read only commands) can be turned into read commands by prefixing the command with a *q*.

Returned data is in the form of a string containing floating point data to 4 decimal places.

Command	***Meaning***	***Send Value***	***Return Value***
Data request *(read only)*			
Test	Communications test	-	Sting "Test"
XInRaw	Pitch in (Input1) PWM width	-	String (data to 4dpl)
YInRaw	Roll in (Input3) PWM width	-	String (data to 4dpl)
ZInRaw	Yaw in (Input5) PWM width	-	String (data to 4dpl)
P7InRaw	Input7 PWM pulse width	-	String (data to 4dpl)
P6InRaw	Input6 PWM pulse width	-	String (data to 4dpl)
P4InRaw	Input4 PWM pulse width	-	String (data to 4dpl)
P2InRaw	Input2 PWM pulse width	-	String (data to 4dpl)
qXRAW	Raw gyro X axis data	-	String (data to 4dpl)
qYRAW	Raw gyro Y axis data	-	String (data to 4dpl)
qZRAW	Raw gyro Z axis data	-	String (data to 4dpl)
qXPST	X axis post processed data	-	String (data to 4dpl)
qYPST	Y axis post processed data	-	String (data to 4dpl)
qZPST	Z axis post processed data	-	String (data to 4dpl)
qPotX	X axis potentiometer gain 0 to 4095	-	String (data to 4dpl)

qPotY	Y axis potentiometer gain 0 to 4095	-	String (data to 4dpl)
qPotZ	Z axis potentiometer gain 0 to 4095	-	String (data to 4dpl)
qExGainX	Real time exact gain pitch	-	String (gain value)
qExGainY	Real time exact gain roll	-	String (gain value)
qExGainZ	Real time exact gain yaw	-	String (gain value)
qAvTemperature	32 second averaged temp.	-	String (data to 4dpl)
Status	Status information	-	String (error code)
Version	Software version number	-	String (version ID)
ProdID	Hardware product ID	-	String (Prod. code)
Self test	Error (0) or all ok (1) message	-	String
***Programming** * (write and read - prefix with 'q' to read)*			
XAxisGain	X axis gyro PID gain	0 to 99.999	String
YAxisGain	Y axis gyro PID gain	0 to 99.999	String
ZAxisGain	Z axis gyro PID gain	0 to 99.999	String
ActivityLED	Switch on/off activity LED	0 off, 1 on	String
ExtYawMix	Mix factor for external YAW	0 to 100	String
GyroYawMix	Mix factor for Z axis rate	0 to 100	String
PWM_out1Bias	Bias value in µs	±999	String
PWM_out2Bias	Bias value in µs	±999	String
PWM_out3Bias	Bias value in µs	±999	String
PWM_out4Bias	Bias value in µs	±999	String
PWM_out5Bias	Bias value in µs	±999	String
PWM_out6Bias	Bias value in µs	±999	String
PWM_out1Inv	Invert output	0 not, 1 inv	String
PWM_out2Inv	Invert output	0 not, 1 inv	String
PWM_out3Inv	Invert output	0 not, 1 inv	String
PWM_out4Inv	Invert output	0 not, 1 inv	String
PWM_out5Inv	Invert output	0 not, 1 inv	String
PWM_out6Inv	Invert output	0 not, 1 inv	String
PWM_inDefault	Default values if no input	0.1 to 99	String
XPPIDgain	X PID proportional gain	0.1 to 9.9999	String
XIPIDgain	X PID integrative gain	0.1 to 9.9999	String
XDPIDgain	X PID derivative gain	0.1 to 9.9999	String
XPIDwindup	X PID windup limit	0 to 99000	String
XPIDMIX	X PID mix factor	0 to 1.0	String
YPPIDgain	Y PID proportional gain	0.1 to 9.9999	String
YIPIDgain	Y PID integrative gain	0.1 to 9.9999	String
YDPIDgain	Y PID derivative gain	0.1 to 9.9999	String
YPIDwindup	Y PID windup limit	0 to 99000	String
YPIDMIX	Y PID mix factor	0 to 1.0	String
ZPPIDgain	Z PID proportional gain	0.1 to 9.9999	String
ZIPIDgain	Z PID integrative gain	0.1 to 9.9999	String
ZDPIDgain	Z PID derivative gain	0.1 to 9.9999	String
ZPIDwindup	Z PID windup limit	0 to 99000	String
ZPIDMIX	Z PID mix factor	0 to 1.0	String
XKalXe	X Kalman filter Xe data	0 to 20000	String
XKalP	X Kalman filter P data	0 to 20000	String
XKalQ	X Kalman filter Q data	0 to 20000	String
XKalR	X Kalman filter R data	0 to 20000	String
XKalF	X Kalman filter F data	0 to 100	String
XKalH	X Kalman filter H data	0 to 100	String

XKalEn	Enable X Kalman filter	1 enable, 0 not	String
YKalXe	Y Kalman filter Xe data	0 to 20000	String
YKalP	Y Kalman filter P data	0 to 20000	String
YKalQ	Y Kalman filter Q data	0 to 20000	String
YKalR	Y Kalman filter R data	0 to 20000	String
YKalF	Y Kalman filter F data	0 to 100	String
YKalH	Y Kalman filter H data	0 to 100	String
YKalEn	Enable Y Kalman filter	1 enable, 0 not	String
ZKalXe	Z Kalman filter Xe data	0 to 20000	String
ZKalP	Z Kalman filter P data	0 to 20000	String
ZKalQ	Z Kalman filter Q data	0 to 20000	String
ZKalR	Z Kalman filter R data	0 to 20000	String
ZKalF	Z Kalman filter F data	0 to 100	String
ZKalH	Z Kalman filter H data	0 to 100	String
ZKalEn	Enable Z Kalman filter	1 enable, 0 not	String
RollAv	Disable rolling average filter	0 to disable	String
RollAv	Rolling Average filter samples	1 to 99	String
XZeroCal	Fine adjustment of zero level	-1.0 to + 1.0	String
YZeroCal	Fine adjustment of zero level	-1.0 to + 1.0	String
ZZeroCal	Fine adjustment of zero level	-1.0 to + 1.0	String
XGyroLockMode	Normal, un-commanded or Proportional mode	0(N), 1(U) or 2(P)	String
XGyroPropMin	Minimum Lock gain	0 to 99.99	String
XGyroPropMax	Maximum Lock gain		String
XGyroPropCen	Central PWM position	0 to 9999	String
XGyroPropMode	Linear or inverse square	0 nor., 1 inv..	String
YGyroLockMode	Normal, un-commanded or Proportional mode	1(N), 2(U) or 3(P)	String
YGPropMin	Minimum Lock gain	0 to 99.99	String
YGPropMax	Maximum Lock gain		String
YGPropCenter	Central PWM position	0 to 9999	String
YGyroPropMode	Normal or inverted	0 nor., 1 inv.	String
ZGyroLockMode	Normal, un-commanded or Proportional mode	1(N), 2(U) or 3(P)	String
ZGyroPropMin	Minimum Lock gain	0 to 99.99	String
ZGyroPropMax	Maximum Lock gain		String
ZGyroPropCen	Central PWM position	0 to 9999	String
ZGyroPropMode	Linear or inverse square	0 nor., 1 inv.	String
XRateTarget	X Rate target	±2000	String
YRateTarget	Y Rate target	±2000	String
ZRateTarget	Z Rate target	±2000	String
BaudRate	Data port baud rate	TBD	String
RTOpt7	Real time PWM input7 options	1 to 7	String
RTOpt2	Real time PWM input2 options	1 to 7	String
RTOpt4	Real time PWM input4 options	1 to 7	String
RTOpt6	Real time PWM input6 options	1 to 7	String
RTX2gain	RT two gain adjust for X	1.5 to 3.2	String
RTY2gain	RT two gain adjust for Y	1.5 to 3.2	String
RTZ2gain	RT two gain adjust for Z	1.5 to 3.2	String
RTXOnOff	RT on/off enable for X	1 on, 0 off	String

RTYOnOff	RT on/off enable for Y	1 on, 0 off	String
RTZOnOff	RT on/off enable for Z	1 on, 0 off	String
RTExactX	RT exact gain for X	0.2 to 5	String
RTExactY	RT exact gain for Y	0.2 to 5	String
RTExactZ	RT exact gain for Z	0.2 to 5	String
RTPIDTargetX	RT PID target for X	±200	String
RTPIDTargetY	RT PID target for Y	±200	String
RTPIDTargetZ	RT PID target for Z	±200	String
RTZMix	RT Z mix gain	0.1 to 2.0	String
RTPowerInX	RT power in mode mix for X	0 to 100	String
RTPowerInY	RT power in mode mix for Y	0 to 100	String
RTPowerInZ	RT power in mode mix for Z	0 to 100	String
PitchInMin	PWM in min pulse width (µs)	1 to 20000	String
PitchInMin	PWM in max pulse width (µs)	1 to 20000	String
PitchInMax	PWM in max pulse width (µs)	1 to 20000	String
PitchInOffset	Central PWM offset	-500 to +500	String
RollInMin	PWM in max pulse width (µs)	1 to 20000	String
RollInMax	PWM in max pulse width (µs)	1 to 20000	String
RollInOffset	Central PWM offset	-500 to +500	String
YawInMin	PWM in max pulse width (µs)	1 to 20000	String
YawInMax	PWM in max pulse width (µs)	1 to 20000	String
YawInOffset	Central PWM offset (µs)	-500 to +500	String
PowerInMin	PWM in min pulse width (µs)	1 to 20000	String
PowerInMax	PWM in max pulse width (µs)	1 to 20000	String
PowerInOffset	Central PWM offset (µs)	-500 to +500	String
PWM_min	PWM out min pulse width (µs)	100 to 65000	String
PWM_max	PWM out max pulse width (µs)	100 to 65000	String
PWM_period	PWM out period (µs)	101 to 65001	String
RoomTp	Room temperature for cal. (^{0}C)	±99.99	String
INVIn1	Input signal inversion	1 or 0	String
INVIn3	Input signal inversion	1 or 0	String
INVIn5	Input signal inversion	1 or 0	String
P2RMix	Pitch to Roll mix %	0 to 99	String
TTurns	Roll into Yaw mix %	0 to 30	String
VTail	VTail mix % (0 disabled)	0 or 100	String
FlapMode	Flap mode	0 to 3	String
FlapTime	Flap deployment total time (s)	0 to 10	String
Flap50	Stage 1 flap position	0 to 80	String
Flap100	Stage 2 flap position	0 to 100	String
FlDown	Modulation flap deployment %	0 to 100	String
BrakeUp	Modulation flap deployment %	0 or 100	String
AirFast	Fast airbrake deployment	0 or 1	String
RevMix	Reverse function of mix	0 or 1	String
RevFlp	Reverse function of flap	0 or 1	String
GyXInv	Invert gyro pitch function	0 or 1	String
GyYInv	Invert gyro roll function	0 or 1	String
GyZInv	Invert gyro yaw function	0 or 1	String
XAGC	Pitch AGC enable	0 or 1	String
YAGC	Roll AGC enable	0 or 1	String
ZAGC	Yaw AGC enable	0 or 1	String
PC tool system commands			
SelfTestEnable	Enables self test tab page	-	n/a
SelfTestDisable	Disables self test tab page	-	n/a

RegisterMapEnable	Enables register map tab page	-	n/a
RegisterMapDisable	Disables register map tab page	-	n/a

* Note: Most of the programming commands can be converted to request data commands by prefixing with a “q”. For example:

To set up the X axis PID gain to 15 the programming command is:

XAxisGain = 15.00;

To check that the correct value has been programmed, the data request command is:

qXAxisGain;

The response (written into the *Rxbuffer* window) is:

XAxisGain : 15.0000;

These commands can be checked out on the PC tool, *tools* page.

4.2 ST L3GD20 registers direct access commands

The following commands are specific to the ST L3GD20 device.

Certain parameters related to:

- Rate data range
- Gyro data rate and cut off
- HPF
- Temperature (uncalibrated)

are set up with special commands that read and write directly to the ST device. In this way any registers of the ST device can be directly programmed and read. The commands are of the form:

L3GD20write 0x2100;

This writes the hex value 0x00 to register 0x21

L3GD20read 0x21;

This returns the hex value of register 0x21. These commands can be checked out on the PC tool, *tools* page.

An example is the acquisition of a single sample of temperature data. The command is shown here:

L3GD20read 0x26;

The response to the above command would typically be as shown here:

Data = 0x1A

4.3 Self Test

The self test feature allows for all the following features to be checked on the BL-3G gyro:

- All inputs and outputs:
- EEPROM
- Gyro device
- Potentiometers

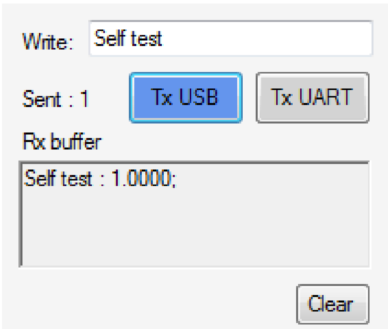
In order to perform the test, first all inputs must be simultaneously connected to the outputs as shown here:

Input 1	->	Output 1
Input 2	->	Output 2
Input 3	->	Output 3
Input 4	->	Output 4
Input 5	->	Output 5
Input 6	->	Output 6
Input 7	->	Output 1
UART Tx	->	UART Rx

The test is entered into by typing in the following command at the tools tab write box window, then pressing the *Tx USB* button (note that this test cannot be performed via the UART interface). The test takes approximately half a second to complete.

If all is ok the following message will be displayed in the Rx buffer window:

Self test : 1.0000;



Any error will be reported as shown here, and only one error message shown at a time:

Error Message	***Meaning***
EEPROM (U2) write :	EEPROM write error
I/O 1 : 0.0000;	Either PMW input 1 or output1 error
I/O 2 : 0.0000;	Either PMW input 2 or output1 error
I/O 3 : 0.0000;	Either PMW input 3 or output1 error
I/O 4 : 0.0000;	Either PMW input 4 or output1 error
I/O 5 : 0.0000;	Either PMW input 5 or output1 error
I/O 6 : 0.0000;	Either PMW input 6 or output1 error
I/O 7 : 0.0000;	Either PMW input 7 or output1 error
EEPROM (U2) read : 0.0000;	EEPROM read error
EEPROM data (U2) : 0.0000;	EEPROM data incorrect
Gyro type (U3) : 0.0000;	Gyro does not respond
Gyro (U3) connect : 0.0000;	Gyro cannot be communicated with
PotX (VR3) : 0.0000;	Pot X (pitch) is not centralized
PotY (VR2) : 0.0000;	Pot Y (roll) is not centralized
PotZ (VR1) : 0.0000;	Pot Z (yaw) is not centralized
USART connect : 0.0000;	UART does not connect
USART data : 0.0000;	UART data is corrupted
Self test : 1.0000;	ALL TESTS PASS OK

5.0 Abbreviations and terms used in this document

PWM	*Pulse Width Modulation*. This is a voltage square wave signal whereby the signal oscillates between its high level and its low level. The pulse width used in this document is the high level. The period is the repetition rate. A typical RC (radio controlled) servo signal will have a high level (at typically 5 volts) for between 1 and 2 ms in duration, followed by a low level such that its repetition rate is in the region of 10ms
Invert	*'Invert'* as it is used in this document refers to the width of the high level of a PWM signal. Typically in RC applications a pulse width high will be between 1 and 2ms in duration. The central position being 1.5ms. A positive deviation from this is towards the 2ms point and a negative deviation towards the 1ms point. A signal's 'inverse' is said to be its deviation from 1.5ms in the opposite way. For example if a signal is say 1.1ms in high level duration this is 0.4ms away from (smaller than, or negative deviation) the central 1.5ms position. Hence its inverse is said to be 0.4ms the other side (larger than, or positive deviation) of the 1.5ms point, and so becomes 1.9ms.
Kalman filter	A *Kalman filter* is a filter that is used in many control applications to remove or reduce the inherent noise in a measurement, even when the precise nature of a particular system model is unknown. It works by estimating the state of a process in a way that minimises the mean of the squared error.
PID	The *Proportional Integrative Differential* algorithm is commonly used in control electronics and systems. It works by feeding back three measurements of a system which, if the system is disturbed from the state in which it is required to be in, are non zero. The weighted sum of these measurements is fed to a controller that moves the system towards its required state. The *Proportional* measurement is the direct deviation or 'distance' the state is away from where it should be. The *Integrative* measurement is the addition over time of all the proportional measurements and gives the controller greater impulse to move the system to its required state if the deviation is prolonged. The *Differential* measurement measures the change of the deviation from one time period to another. In other words if there is little improvement over time to make the system move to the desired state this measurement will give the controller further impulse to move the system in the direction required.
Pitch	*Pitch* is the movement of an aircraft in the nose up attitude. I.e. positive pitch is nose up and negative pitch is nose down.
Roll	*Roll* is the downward movement of an aircraft starboard side wing. I.e. positive roll is a movement of the starboard wing down in order to turn the aircraft to the right. Negative roll is a movement of the portside wing down in order to turn the aircraft to the left.
Yaw	*Yaw* is the motion of an aircraft (within the plane of its wings) in a clockwise rotation. I.e. positive yaw is a clockwise motion and negative yaw is an anti-clockwise or counter clockwise motion.
UART	The *Universal Asynchronous Receiver / Transmitter* is a simple two (or sometimes four) wire, two way communications system with no common clock. Each side of the communication must generate its own clock for data recovery.
Baud rate	The *baud rate* is the number of symbols transmitted per second in a

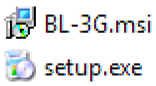
	communications system. Not to be confused with the data rate. A distinction is made since, for example, for a UART there may be one stop bit used for every 8 bits of data used as part of the low level protocol and so the useful data rate is reduced. (Modified by a factor of $8/9^{th}$).
Quad-Rotor	An aircraft with four rotors all pointing in the same upwards direction.
Aileron	The control surface part of an aircraft wing used to move the aircraft in roll.
RPM	*RPM* is revolutions per minute, a standard way to measure propeller and motor speed.
RC	*Radio controlled*
Gain	The amplification of an electronic system (or software algorithm).
MEMS	*Micro-Electro-Mechanical-Systems*. Now incorporated onto the silicon wafer of an IC (integrated circuit).
Servo	A *servo* is a mechanical system whereby an input PWM signal is converted to a physical movement of a mechanical arm. Typically referred to as either standard or digital. A standard (sometimes called analogue) servo has custom logic while a digital one typically has a microprocessor, a power switch and amplifier. A digital servo will have faster response, constant torque and smoother overall acceleration/deceleration, better resolution and also holding power. A disadvantage is a slight increase in power consumption. Standard servos operate at typically 50Hz with digital ones going as fast as 333 Hz (3ms repetition frequency), however the central pulse high period is still typically centred on 1.52ms with 0.5ms either side. Non standard may also use a 'narrow pulse' of 760 µs instead of 1.52ms.
LPF	*Low Pass Filter.* Allows only low frequency signals to pass, thus reducing the effect of unwanted noise in the signals.

6.0 PC Set-up tool installation

Step 1

Do not plug your BL-3G gyro into your PC yet.

Insert the supplied CD into your PC drive and find the two files as shown here:



Note that most updated files are available at our website at: http://www.bluelight-tech.com/Downloads.htm
Please make sure to always check here for updated PC tool software and also for BL-3G firmware.

Step 2

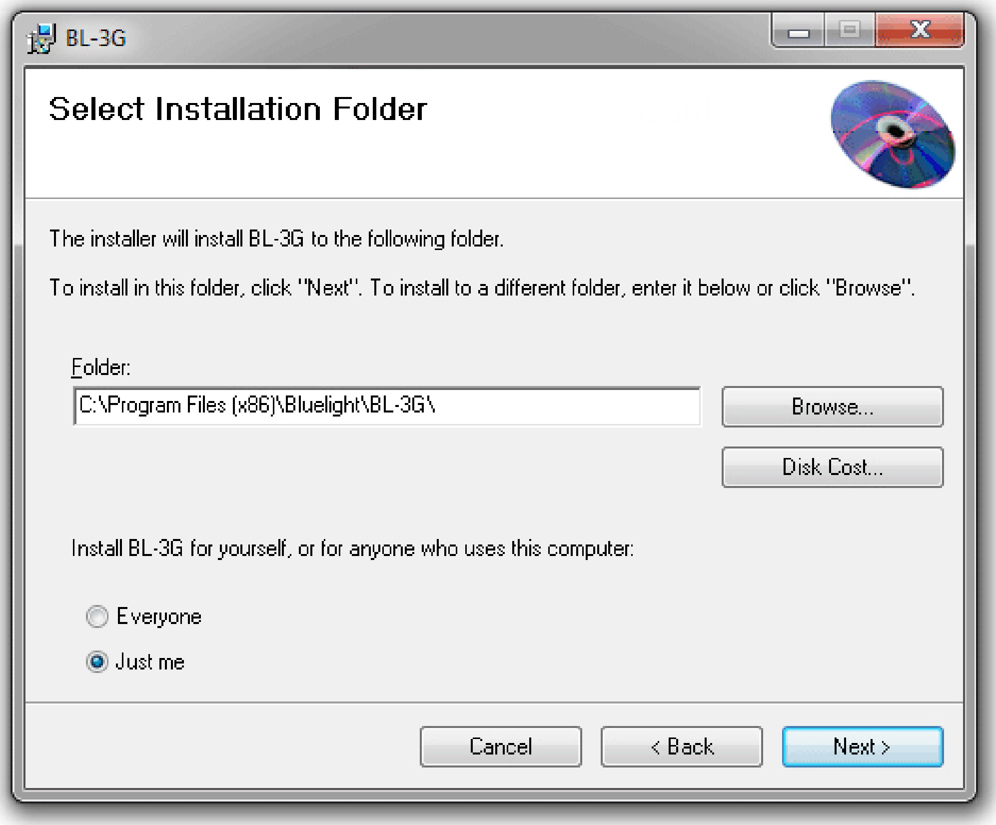
Double click on the ***setup.exe*** file. If you don't have the **.NET** (pronounced "dot net") framework installed on your PC you will be prompted to install this first. Follow Microsoft instructions to do this. .NET is a framework that allows executable files to run within a Windows protected environment. Most modern PCs have this software pre-installed, but not all.

Then repeat this step again. You will see the following screen pop up:

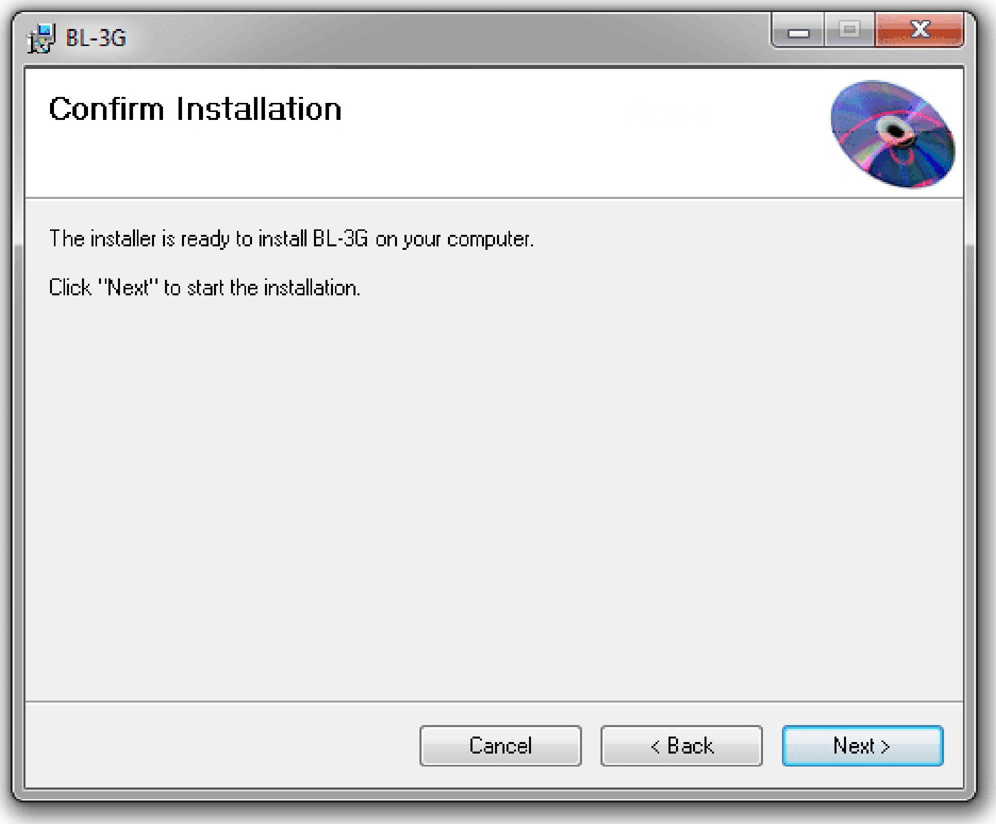
Press *next* to continue.

You will then see the next screen..

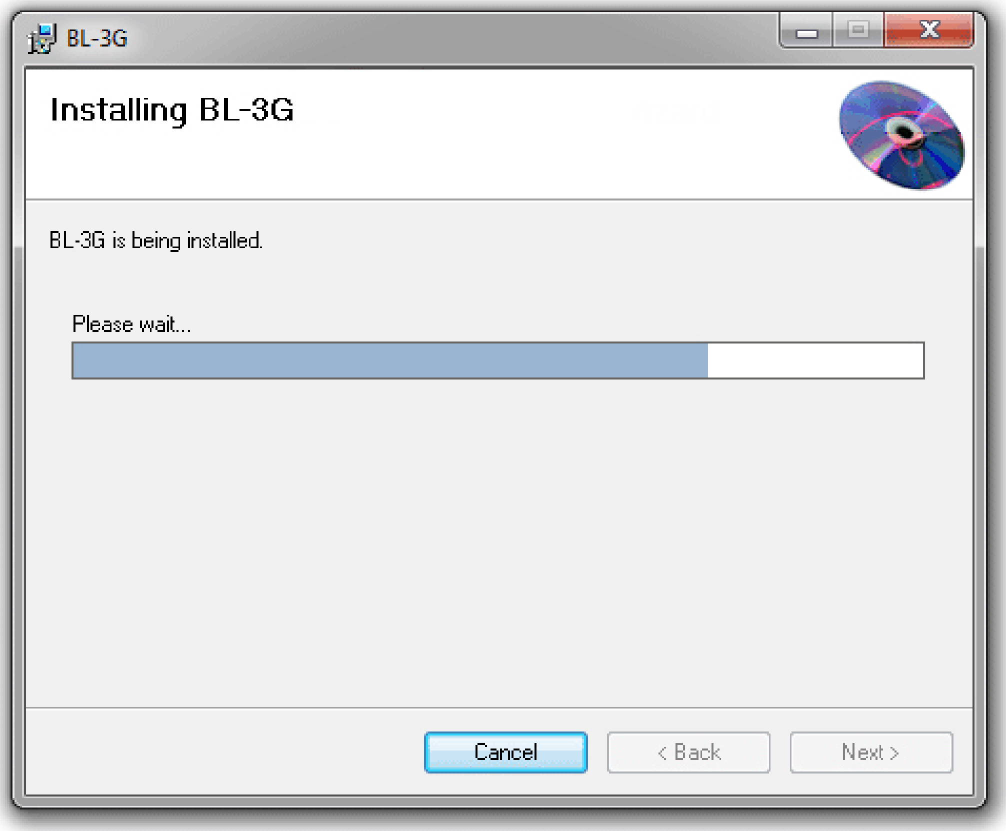
Press *next* to continue, to see the next screen**.**



You may choose to change your default directory, but it is strongly recommended that you leave it unchanged. The next screen will be:

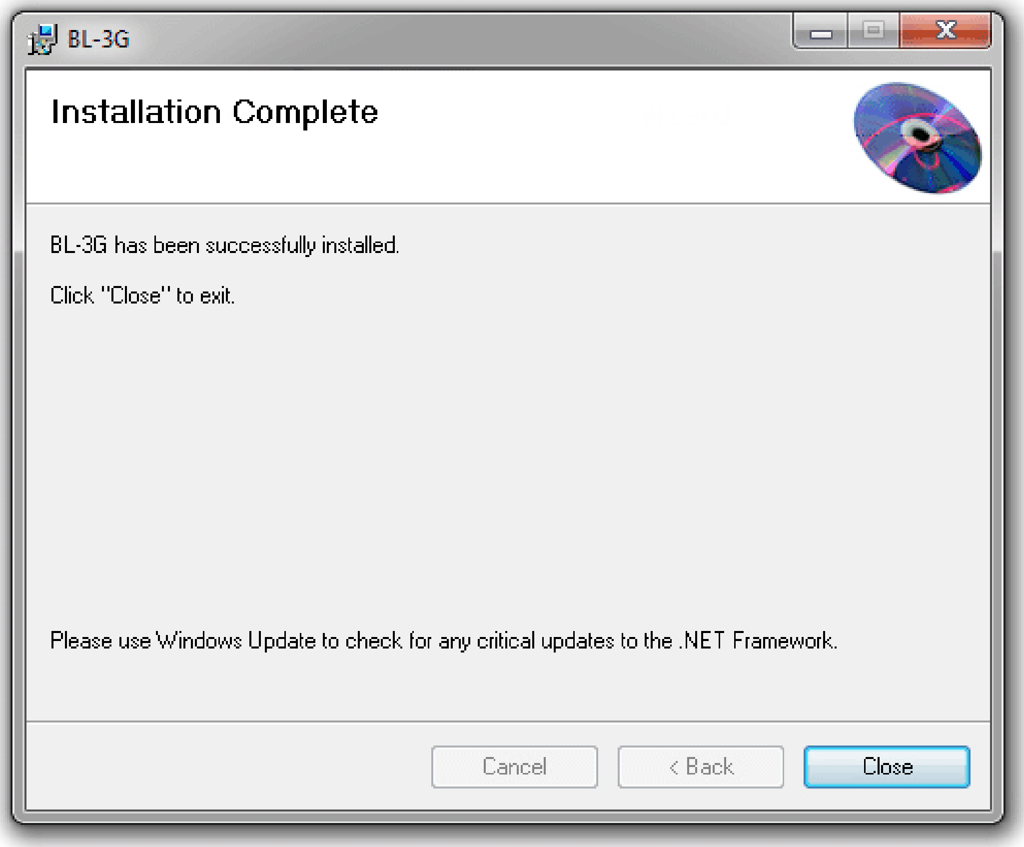


Followed by..



Note that the screen may remain with no progress being shown for up to 20 seconds or so.

Finally you will see the following screen..



Step 3

Find the executable file on your PC. It should be available in three locations:

1) As an application in the User's Program Menu section of your PC. This is In the *All Programs* section of your start button menu (for a Windows 7 machine).

2) An application will reside inside the directory *Bluelight Technologies* of your User's Program Menu section of your PC.

3) As a desk top icon 

Double click to open up the application.

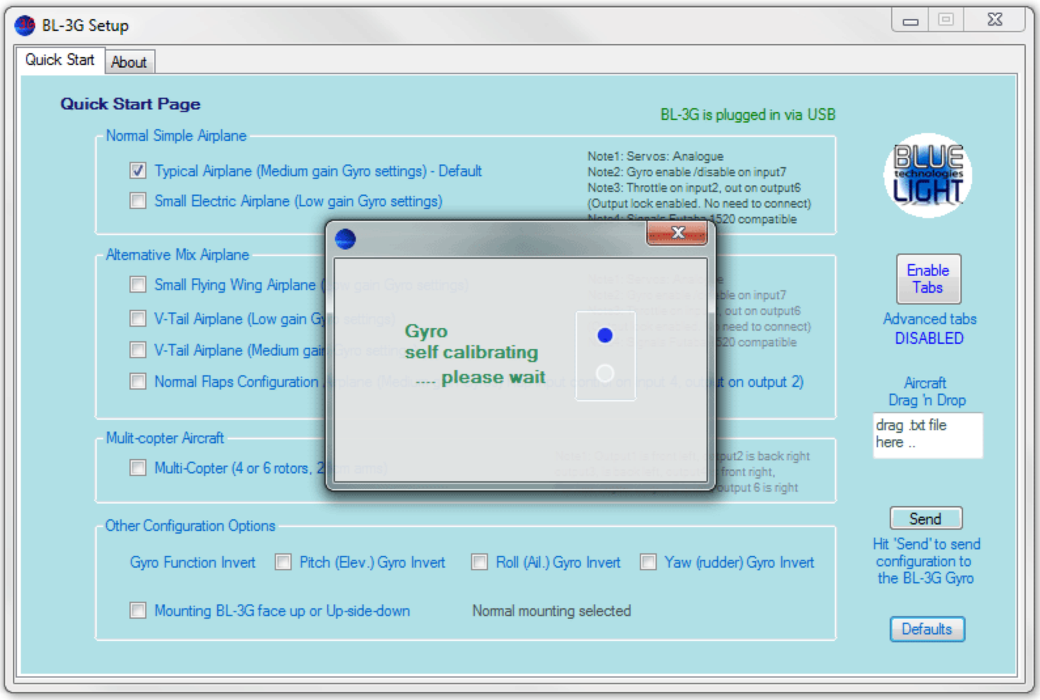
Step 4

The start-up screen will appear as shown here:

Verify that you see the above with the message **BL-3G NOT plugged in via USB** at the top.

Step 5

Now plug the supplied USB cable into the BL-3G and also into your PC. No other connections at this time. You will now see the following:



The gyro is self calibrating. During this time it is important not to move the BL-3G gyro in any way. Please follow this rule whenever the BL-3G gyro is being powered up.

After a few seconds it will complete. You should now be able to see the message at the top saying: **BL-3G is plugged in via USB**.

Note that on first connection of the BL-3G to the PC via USB you should also see one **red LED** on the gyro when the USB is connected (this is the power LED), followed by two seconds when the **blue LED** will flash (then go out). When calibration is complete the blue LED will continue to flash. The blue LED is indicating that the firmware inside the BL-3G is running normally.

This then completes the installation procedure and you are ready to go to section **2.1** detailing the PC set-up tool.

be ultra cool, be ultra stable
.... with the ICE-MAN Gyro.

Bluelight Technologies accepts no responsibility for any damage to property, or injury to any person or persons caused by the use, incorrect or otherwise, of this product. It is the user responsibility to confirm correct connection and operation prior to any use, and to act responsibly at all times.

See http://www.bluelight-tech.com/BL-3G.htm for more information
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Muangnonthaburi, Nonthaburi 11000.